MACHINE DESIGN

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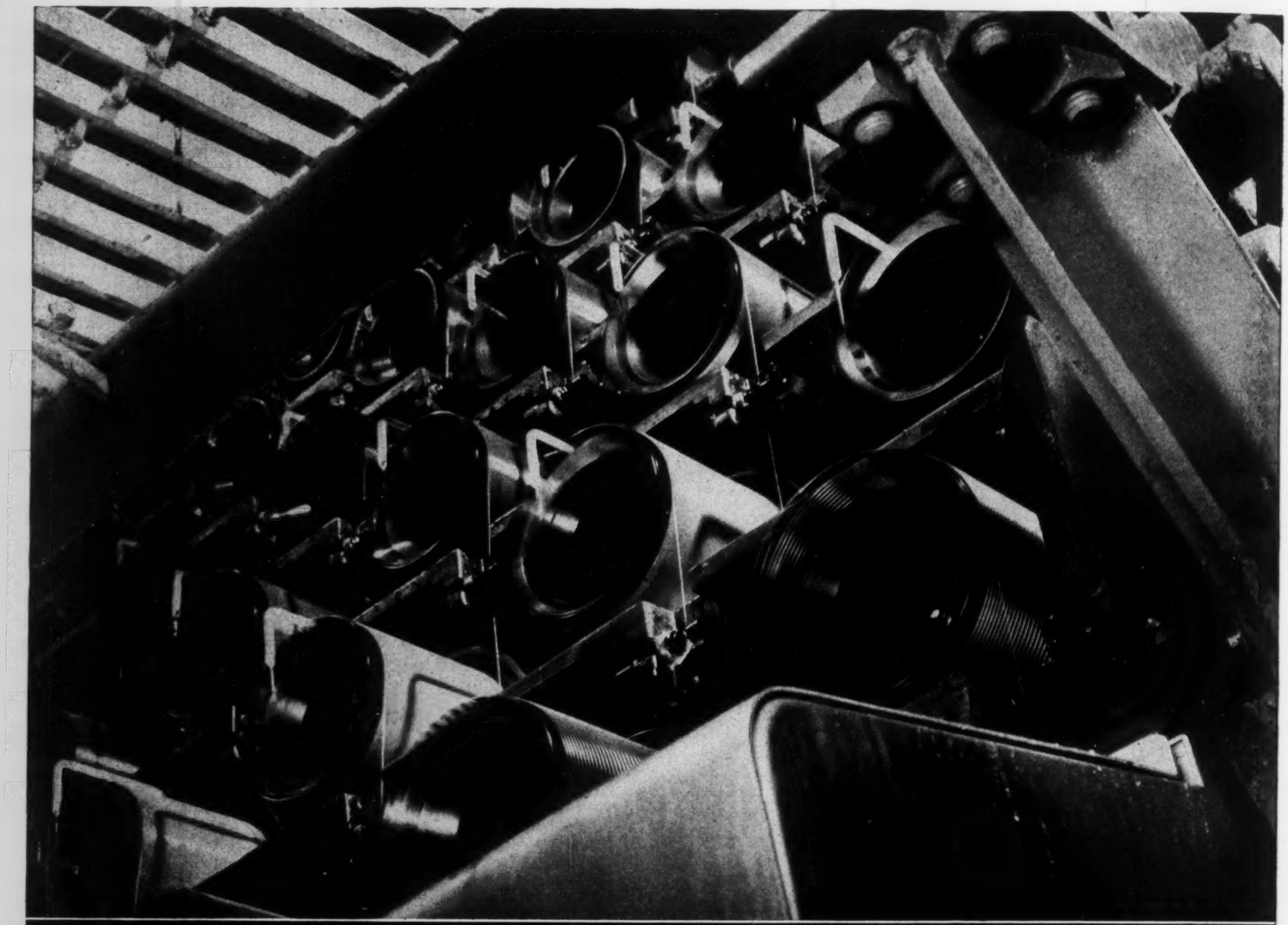

Now it's Rayon by the MILE in a new continuous process

Another New Development Aided by New Departure

- Engineering by New Departure assisted the Rayon Machinery Corporation in development of machines for the first continuous process viscose rayon plant built by Industrial Rayon Corporation at Painesville, Ohio.

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These grease-packed bearings made the project commercially possible—they simplified design, accurately and permanently locate rotating parts, eliminate periodic oiling, cut power consumption and greatly reduce costs.

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New Departure self-enclosed ball bearings have simplified design, cut manufacturing and maintenance costs, in thousands of machines and appliances. It will pay you to check their many advantages in relation to your own designs. Send now for packet X-5

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New Departure • Division General Motors Corporation • Bristol, Connecticut

NOTHING ROLLS LIKE A BALL

Itemized Index

CLASSIFIED FOR CONVENIENCE WHEN STUDYING SPECIFIC DESIGN PROBLEMS

KEY: EDIT., EDITORIAL PAGES; ADV., ADVERTISING PAGES; R, RIGHT-HAND COLUMN; L, LEFT-HAND COLUMN

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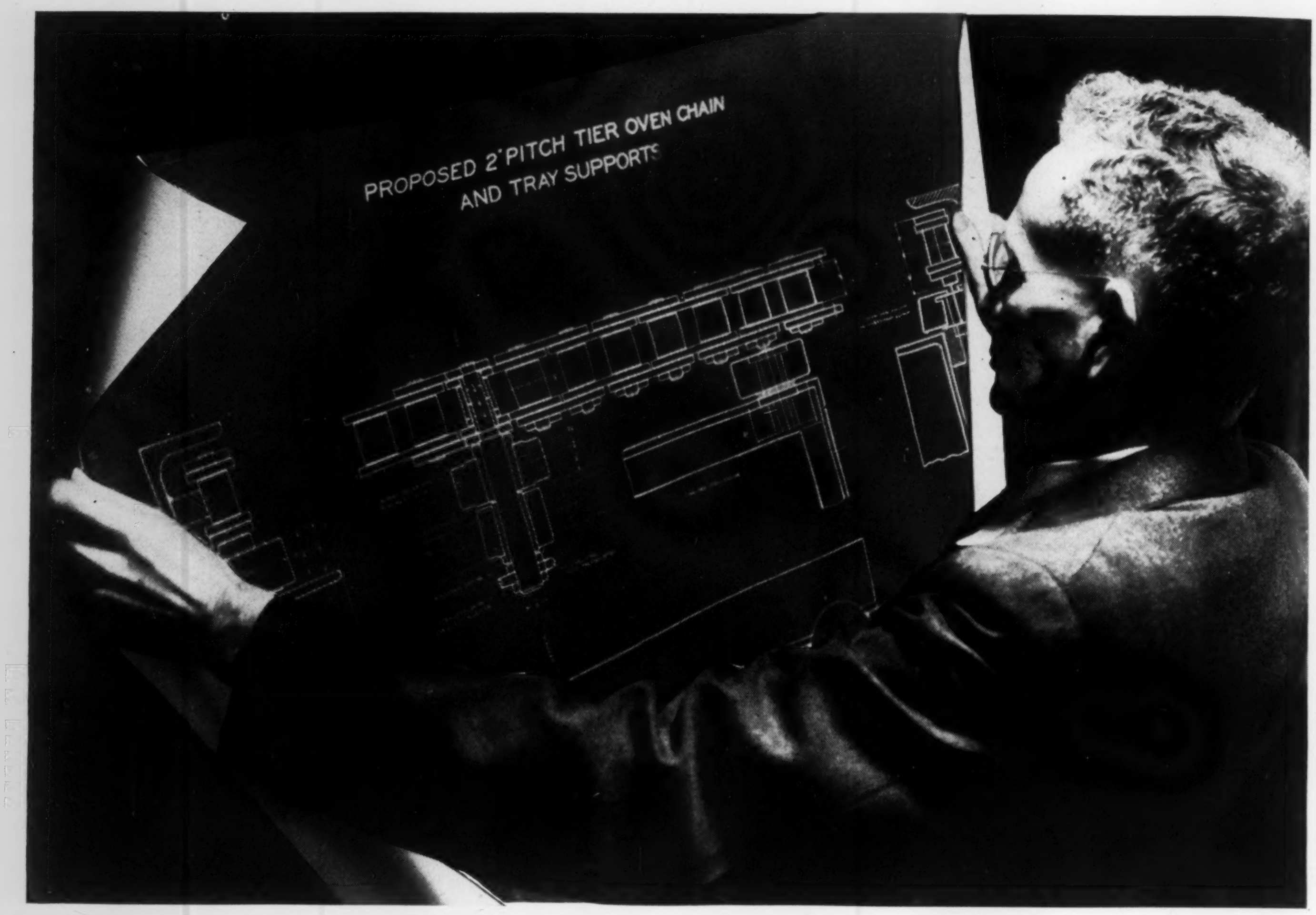
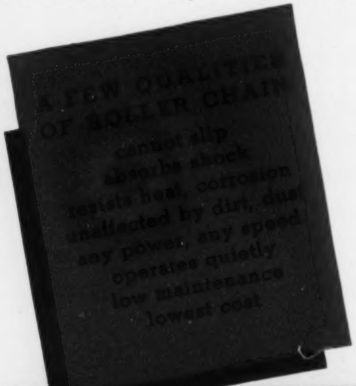

PROPOSED 2" PITCH TIER OVEN CHAIN
AND TRAY SUPPORTS

Design for Better Biscuits

Diagramed here is a case where intelligent cooperation between Baldwin Roller Chain engineers and a nationally known biscuit company worked out the solution of a troublesome problem. Results: Better baked biscuits for the tables of the land—at a lower manufacturing cost.

An important factor in designing any machine is to know which particular type of drive is best suited for the job. We know and can demonstrate to you how modern Baldwin Roller Chain has set new standards by its strength, high speeds, long life, resistance to heat, dust, dirt and corrosion.

By putting our heads together we can do for you what we did to make better biscuits. Why not call the B-D Man today?


A FEW QUALITIE
OF ROLLER CHAIN
cannot slip
absorbs shock
resists heat, corrosion
unaffected by dirt, dus
any power, any speed
operates quietly
low maintenance
lowest cost

BALDWIN-DUCKWORTH CHAIN
CORPORATION
SPRINGFIELD, MASSACHUSETTS
Factories at Springfield and Worcester, Mass.

BALDWIN-
DUCKWORTH

Take Your Cue from the Bosun's Crew

In the days of wooden ships and iron men every bit of muscle had to count. Today, positive roller chain and sprocket drives are the modern application of the bar-in-capstan idea for conditions where power waste is taboo.

Present Users Proved the Point

They never shake loose!

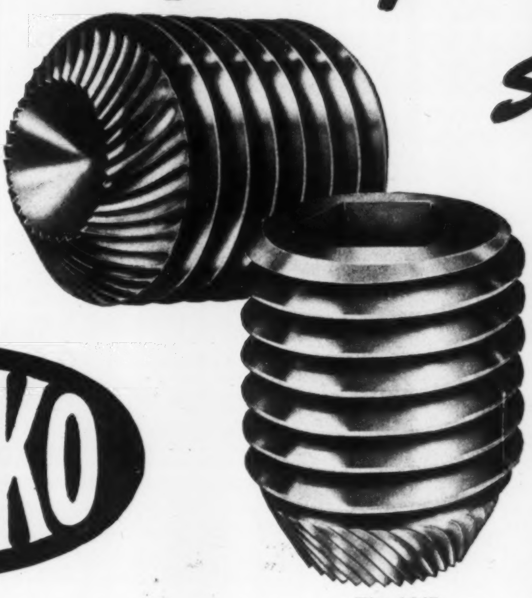


Fig. 1645
Pat. App. for

UNBRAKO

Proved conclusively that the "UNBRAKO" Set Screw cannot loosen up in service . . . that the ingenious knurling around the cup point locks the screw securely when it's merely tightened in the ordinary way. Proved: "We've got something here!"

SELF-LOCKING HOLLOW SET SCREWS

• Knurled Points •

To avert accidents and prevent breakdowns caused by set screws loosening up, you should, by all means, use the new "UNBRAKO" Set Screws with the Self-Locking Knurled Point. Once set up, it cannot fail to hold, yet it can be removed for adjustments and reused again and again.

It's a real answer to breakdown problems . . . proved by usage in many different plants and under varied conditions.

And, that is why we say you're passing up a good bet if you fail to get the "UNBRAKO" samples and detailed information that are yours freely for the asking. The coupon below brings them to you; rip it out and mail it NOW!

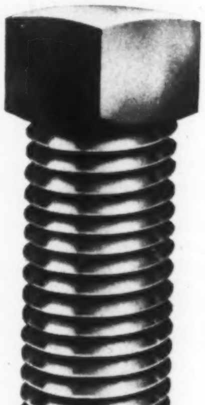


Fig. 1646
Pat. App. for

Knurled Point on the UNBRAKO Self Locking Square-Head Set Screw, too!

The Square-Head Set Screws used and liked by industry for years also can be had now with the automatic self-locking feature provided by the knurled cup points. And, like the Knurled Point Set Screw, they hold tight —yet are easily removed with ordinary tools, and used over and over again.

Get Bulletin!

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Send me samples and all the facts about

☐ "UNBRAKO" Self-Locking Hollow Set Screws.

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Company ....

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From the Research

THE WORLD'S LARGEST MAKE OF

IMPROVED Super-Flex D

W

Outstanding in Basic Scientific Design—the Improved Super-Flex Dayton Cog-Belt wit Daytex Cord Gives You These EXCLUSIVE Advantages of Cooler Running, Longer Lif

Built to Bend

In Dayton's convolute layer construction the entire belt is built to bend—less internal strain—longer life. And because of the cross-wise regidity, Dayton Cog-Belts ride true in the pulley grooves. No twisting—no distortion—cooler running, longer life.

COGS
"CLOSE UP"
WHEN BENT

Patented Cog Construction

Dayton's patented cogs close up when the belt goes around the pulley—and take up the compression on the inside of the belt. Another reason why Super-Flex Dayton Cog-Belts are more flexible—cooler running and longer lasting.

Greater Gripping Power

Because of their die-cut sides Dayton Cog-Belts have greater gripping power—the highest coefficient of friction of any belt.

Laboratories of

F V-BELTS COMES THIS

DAYTON COG-BELT WITH DAYTEX CORD

In millions of applications, Dayton Cog-Belts have established remarkable records for long life—for the delivery of smooth, silent, constant driving power at low cost. Now, Dayton, the pioneer in the latexing of cord for V-Belts, brings you another revolutionary development—the improved Super-Flex Cog-Belt made with Daytex Cord.

Cooler Running

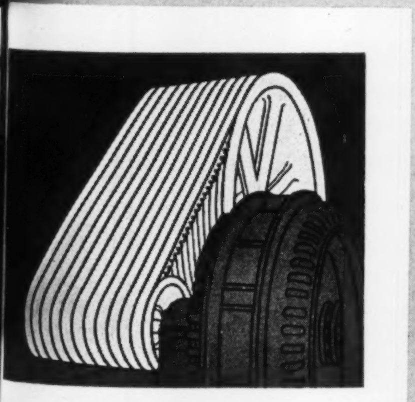
Cooler running because it defeats life destroying internal heat, this improved Super-Flex Dayton Cog-Belt with Daytex Cord is the result of 7 tireless years of tests and research by Dayton's famed technical laboratories. This long-lived Daytex Cord—with inter-locked non-slip fibres—latex processed by exclusive patented Dayton equipment—sets an entirely new standard of strength and compactness—it's a cord with minimum stretch—a cord with super-flexibility.

Longer Life—Fewer Adjustments

Today, this compact, Super-Flex, stronger Daytex Cord in the neutral section of Dayton V-Belts sets a new standard of long-lived power transmission. The improved Super-Flex Dayton Cog-Belts last longer than ever before. Maintenance costs are still lower because fewer adjustments are necessary! No slip—no stretch. These Super-Flex Daytons deliver positive, dependable, shock-proof power.

Learn first-hand what this improved Super-Flex Dayton V-Belt can mean to you in increased production with lower cost. Write for the facts today.

THE DAYTON RUBBER MFG CO.
DAYTON, OHIO



Whether for fractional or a thousand horsepower—there is a Dayton V-Belt Drive for the job.

Super-Flex

Dayton

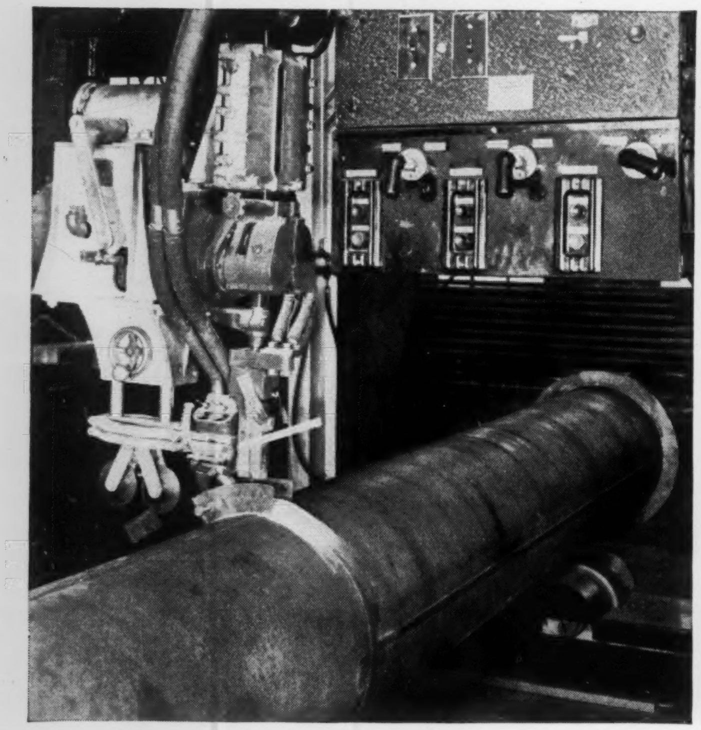
COG-BELT DRIVES

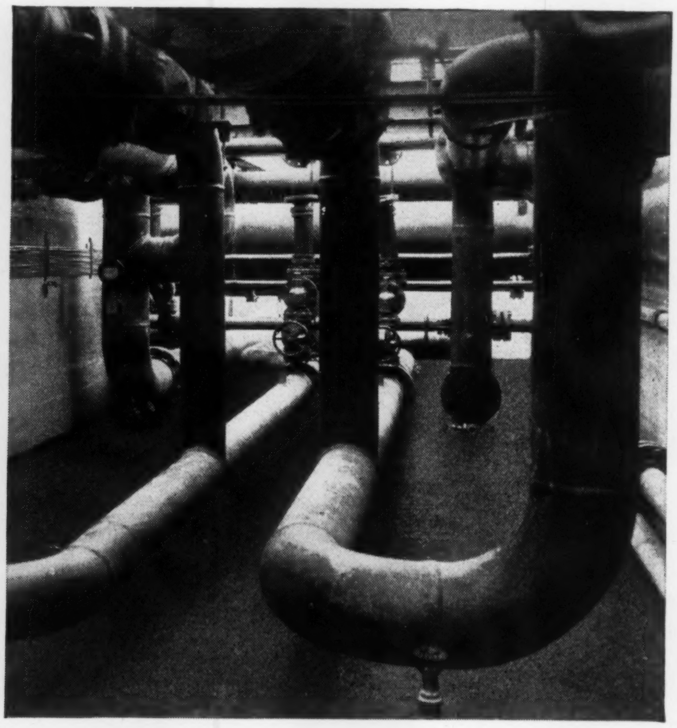
WITH DAYTEX CORD

MADE BY THE WORLD'S LARGEST **D** MANUFACTURER OF V-BELTS

More Power to You

New Linde processes for fabricating pressure vessels and for joining pipe assure long, dependable service





UNIONMELT WELDING: A speedy, dependable, automatic welding process is now available in Unionmelt Welding—an electric welding process—which is shown here making a girth weld on a Par. U-68 (Class 1) type pressure vessel. This vessel has a wall thickness of 5/16 inch, and the weld was made in one pass at 19 inches a minute. Unionmelt welds have met the rigid specifications of the A.S.M.E. code for fired power boilers and of Par. U-68 (Class 1) for high-test type pressure vessels, and have been accepted by various insurance and inspection organizations.

LINDEWELD MULTI-FLAME PROCESS: Strong and tough welds of uniformly high quality can be obtained when piping systems are joined by the Lindeweld Multi-Flame Process which employs the new Oxweld 6- and 4-flame welding tips and high-speed welding rod. These welds, properly made, are permanently leakproof and require no further attention. Also, they are ductile and are as corrosion-resistant as the pipe base metal. The Lindeweld Multi-Flame Process is fast and consumes a minimum of oxygen and acetylene in the installation of piping systems.

Many economical applications of these new Linde processes can be utilized by power consuming industries. Any Linde representative will gladly discuss them with you. Write the nearest Linde office for further information.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

New York and UCC Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

Everything for Oxy-Acetylene Welding and Cutting

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES • UNION CARBIDE

The words "Linde," "Prest-O-Lite," "Oxweld," "Lindeweld," "Union" and "Unionmelt" are trade-marks of Units of Union Carbide and Carbon Corporation.

You can see demonstrations of machine-cutting, including the Oxweld CM-15 Cutting Machine—flame-hardening—and the welding of oil well casings with the new Oxweld multi-flame tips—at the Linde exhibit, Area 109-115, Oil-World Exposition, Houston, Texas, April 24-29, 1939.

The Story of the Puzzling Pump

AND HOW DU PONT NEOPRENE HELPED TIMKEN MAKE IT FOOLPROOF

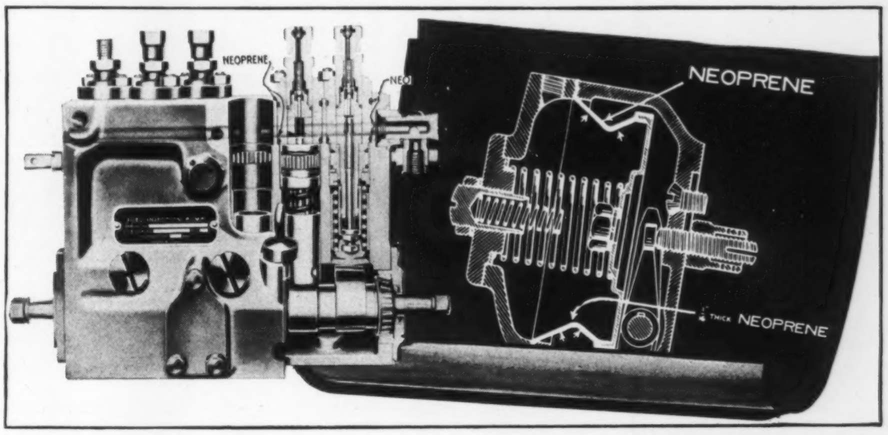
A FEW YEARS AGO, the Executive Engineer of a leading machine parts manufacturing concern was making an inspection trip through a branch factory when he was hailed by a group of men in a corner of the power house.

"Come take a look at this sick diesel fuel injection pump," they said. "Can we fix it, or shall we just take it out and give it a decent burial?"

The Executive Engineer looked at the pump and scratched his head. You know what he was up against . . . for in those days a fuel injection pump was as complicated as a Chinese puzzle.

"Boys," he said finally, "you've got me. Better wire the people who made it. And I'm going to see what I can do about getting a simplified yet efficient pump."

He did. Others did too. And that's what led the Timken Roller Bearing



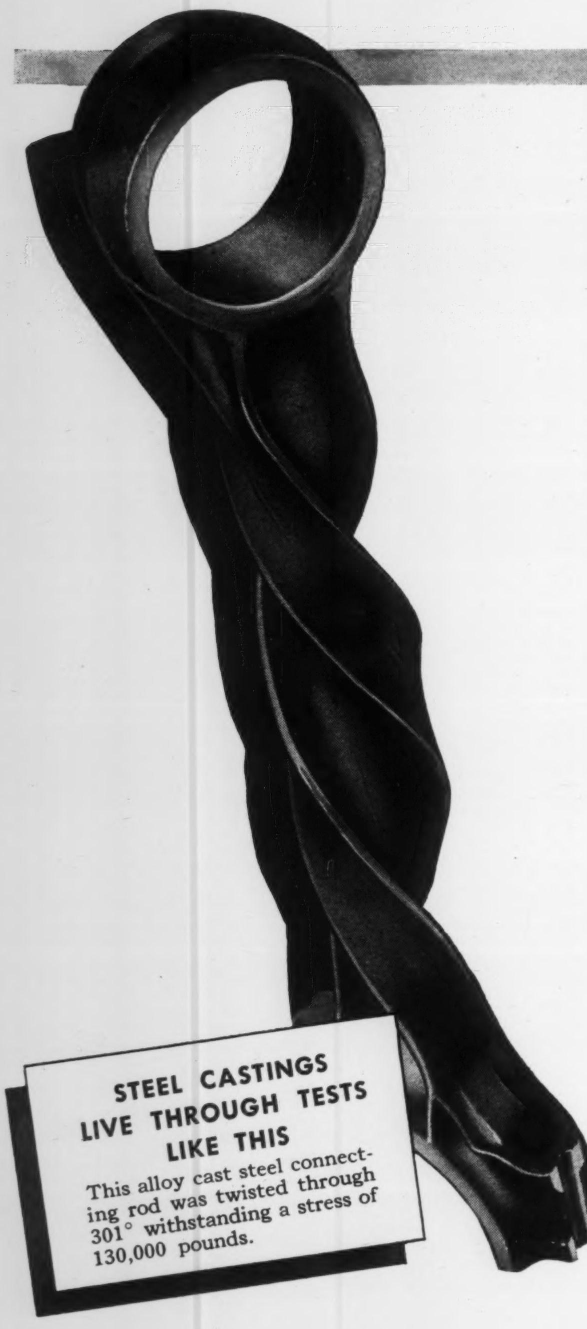
Company to design a fuel injection pump so simple and reliable that almost any mechanic could understand it. In this new pump the number of separate parts was minimized. Whole sections were made easily replaceable.

One of the factors which made this improved pump possible is the unique performance of neoprene, Du Pont's chloroprene rubber, in the presence of oil and heat. Neoprene sealing units are used extensively . . . in the mechanical governor, in the center shoulder of the pumping unit, on the control shaft, and in many other places. In the vacuum-type governor, too, neoprene is an important part of the bellows and diaphragm assembly.

So, thanks in part to neoprene, fuel injection pumps are available that aren't necessarily puzzling... one of the thousands of cases where neoprene has helped solve design problems. We hope that this story will suggest ways in which neoprene can be useful to you too. Keep abreast of new uses of neoprene by writing for your subscription to the free, monthly, newsy "Neoprene Notebook."

DU PONT
REG. U. S. PAT. OFF.
NEOPRENE
E. I. du Pont de Nemours & Co., Inc.
Rubber Chemicals Division
Wilmington, Delaware

WHY THIS *Twisted* CONNECTING ROD MAKES *Better* ENGINES



STEEL CASTINGS LIVE THROUGH TESTS LIKE THIS

This alloy cast steel connecting rod was twisted through 301° withstanding a stress of 130,000 pounds.

Steel Castings that pass tests like this — many times as severe as the demands of actual operation — make better machines. They provide extra strength without useless weight. They have the rigidity that insures permanent alignment, yet they stand sudden shocks and strains.

They save time, because they require less machine finishing. They permit scientific metal distribution. They resist corrosion, wear and fatigue.

STEEL CASTINGS BRING YOU THESE ADVANTAGES

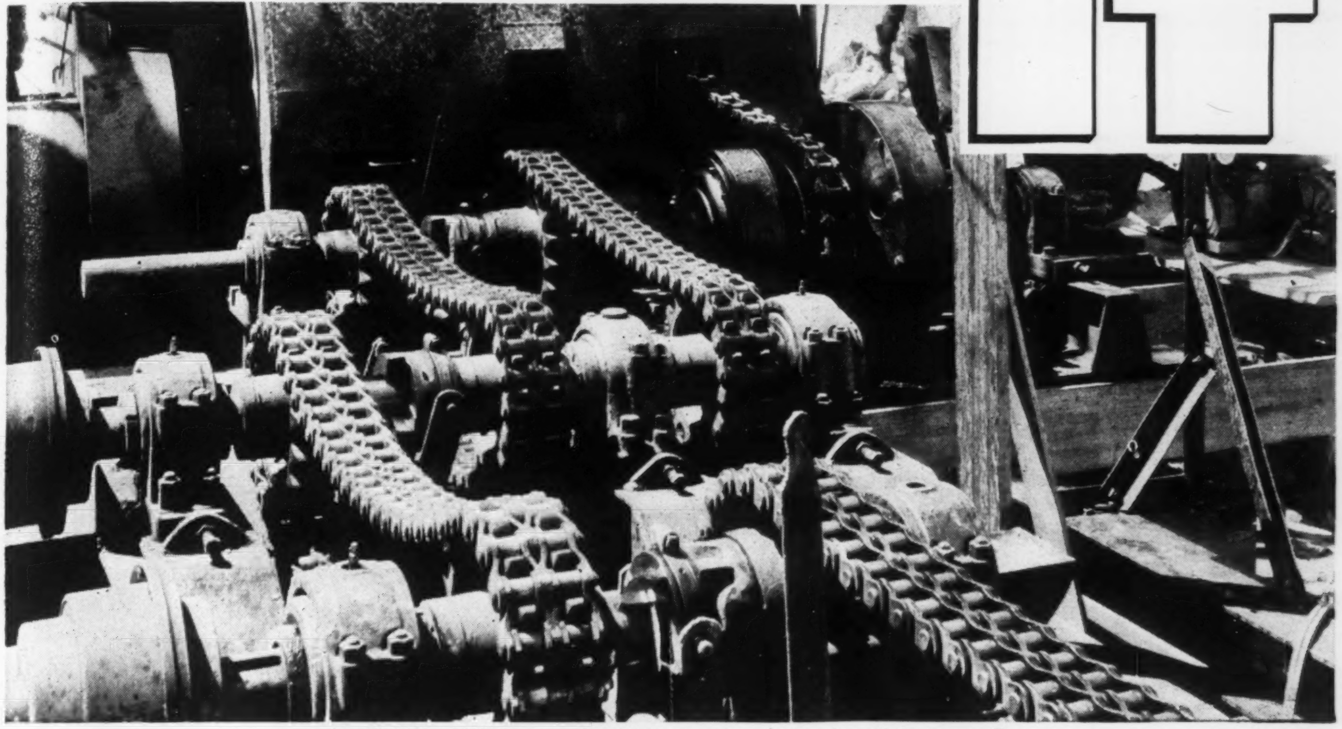
1. Uniform structure, for greater strength, shock and stress resistance.
2. Metal distributed where it will do the most good; maximum strength with minimum weight.
3. Widest range of physical properties.
4. Good machining qualities, low finishing costs, better streamlined appearance.
5. High rigidity, minimum deflection, accurate alignment, close tolerances and better fit.
6. Readily weldable in composite structures.
7. High fatigue resistance, maximum endurance and longer life — ideal for critically stressed parts.

Steel Castings can make *your* product better, and save you money. Consult your own foundry, or write to Steel Founders' Society, 920 Midland Bldg., Cleveland, Ohio.

IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

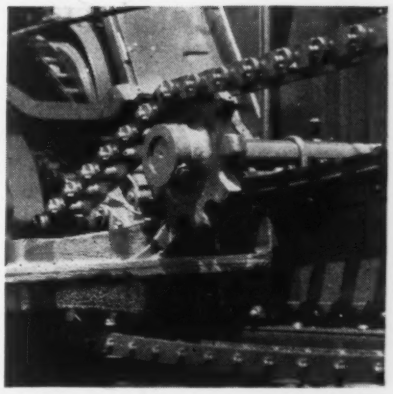
HOW TO HANDLE IT



Rex Chabelco on drilling rigs in the oil fields means lower cost per foot of hole on any well.

IF *IT* IS HORSEPOWER

Driving high-speed rotary rigs in the oil field is the toughest, heavy-duty, high-speed work that chain or any other type of transmission equipment is ever asked to do. *Rex Chabelco chains are among the most popular for this service.* They were used in drilling KCL-A2—the world's deepest hole—and are found on rigs the oil world over.



Powerful chain crowds, driven by Rex Chabelco Chain, force heavy shovel dippers into toughest soils —a great aid in modern high-speed digging.

Chabelco has what your drives need!

Wherever economical power transmission is important to profitable operation, Rex Chabelco Chains can be the answer. They have become standard in all types of industries for use on high-powered drives, where starts and stops are frequent, loads are heavy and work is continuous. They are built in all sizes and types. Ask the "How to Handle It Man" which of the Chabelco series will give you the economy and reliable service you want on tough drives.

Use this coupon to bring you your copy of "How to Handle It in Every Industry," a folder describing the complete Rex line.

CHAIN BELT COMPANY
1643 West Bruce Street, Milwaukee, Wis.
Please send me my copy of "How to Handle It in Every Industry."

*Firm Name*____________________

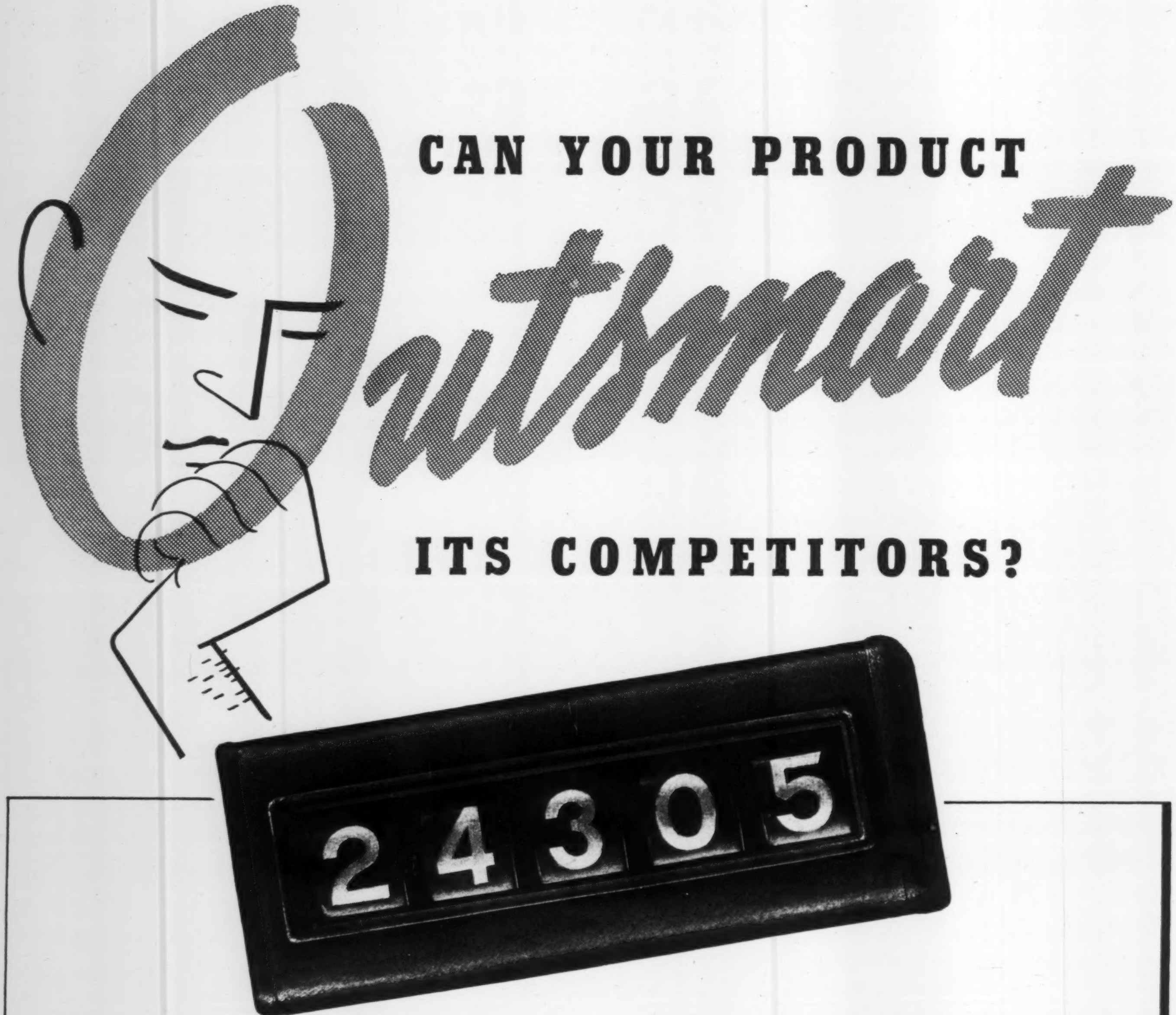
*By*____________________

*Title*____________________

*City*____________ *State*__________

REX DRIVE AND CONVEYOR CHAINS FOR THE MACHINERY INDUSTRY

CHAIN BELT COMPANY of Milwaukee



CAN YOUR PRODUCT Outsmart ITS COMPETITORS?

Machines—as well as men—need brains to get along. That's why you find so many manufacturers building into their products "heads for figures"—Veeder-Root Counting and Computing Devices.

Veeder-Root Counting Devices have made many machines practically human. Gasoline pumps use them to do their arithmetic—convert gallons into dollars and cents. Night deposit boxes have them as mechanical tellers—to count, *with accuracy,* deposits. Telephone switch-boards use them to check the length of calls. And in many other cases Veeder-Root Devices are used to give products more brains—to help them do more—to help them *sell* more. The applications of Counting and Computing Devices are unlimited. Veeder-Root Engineers are constantly working with manufacturers—finding new ways to make products more useful and salable, with built-in counting devices.

It might pay you to see if a Counting Device can help *your* product "out-smart" its competitors.

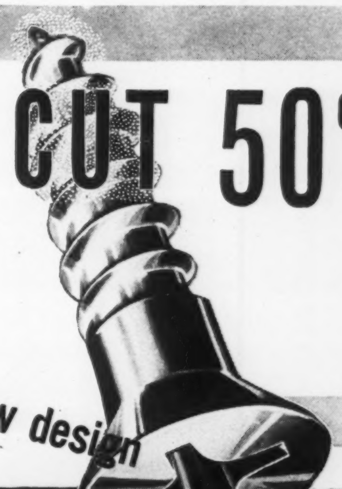
Write for the interesting Veeder-Root booklet "Counting Devices"
It shows many of the unusual applications of Veeder-Root Counting Devices—gives a clear picture of their possibilities—offers ideas that lead to sales.

VEEDER-ROOT
Counting Devices
BUILDERS OF COUNTING DEVICES SINCE 1878

VEEDER-ROOT INC.
HARTFORD, CONN.
Offices in Boston, Chicago, Cincinnati, Cleveland, Detroit, Greenville, S. C., Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, Montreal, Buenos Aires, Mexico City, London, Paris, Tokyo, Shanghai, Melbourne

ASSEMBLY COSTS CUT 50%

and more by single simple change in screw design



PHILLIPS RECESSED HEAD SCREWS REPLACE SLOTTED SCREWS ON FAMOUS MAKES OF MOTOR CARS, ELECTRICAL APPLIANCES, FURNITURE

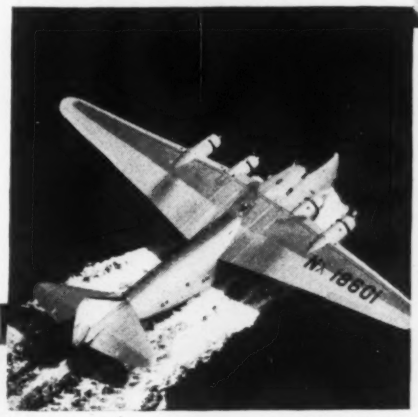
Production schedules speeded up . . . spoilage eliminated . . . appearance and holding power improved — that's the report from manufacturers who lead the way in adoption of Phillips Recessed Head Screws.

Priced slightly higher, Phillips Screws make such large savings in assembly time, that total production costs are much reduced. Delays and spoilage previously caused by slipping drivers are eliminated by the design of screw head which holds the driver in the recess.

Phillips Screws set up tighter with less effort and without split heads, thus increasing resistance against loosening, decreasing service required.

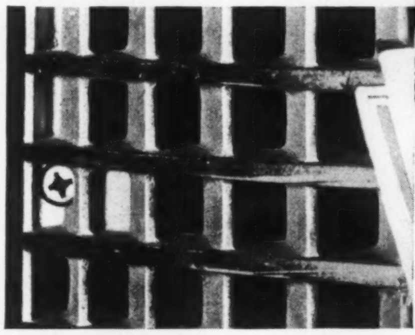
80,000 PHILLIPS SCREWS TO CROSS ATLANTIC

Boeing's new Atlantic Clipper assembled with tighter-holding Phillips Screws.



DESIGN ENGINEERS SEE SIMPLER FASTENINGS

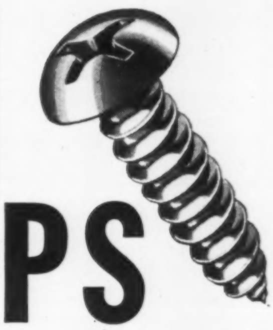
Leading automotive manufacturer now uses Phillips Screws which do not need locking devices. Counter-sunk finishing washers can also be eliminated.



More Frequent Use of Power Drivers Due to Patented Phillips Screw

Freedom from threat of a slipping driver means faster driving methods can be used. Many manufacturers now use power drivers on jobs where caution used to demand a slower, more costly method.

Elimination of pilot holes; straight-line driving (leaving one hand free to steady the work); prevention of burrs due to close fit of driver and screw — all contribute to further time savings and better-quality work.



GENUINE PHILLIPS RECESS . . . THE HEAD CAN'T SPLIT

The taper and depth of the Phillips recess resulted from months of research to determine the shape which would utilize the driver's maximum turning power without sacrifice of strength in the screw head. Four sizes of Phillips Drivers provide greatest efficiency for the entire range of Phillips Screw sizes. Two driver sizes fit diameter #5 to #16 inclusive.

PHILLIPS

RECESSED HEAD SCREWS

U. S. Pat. on Product and Methods Nos. 2,046,343; 2,046,837; 2,046,839; 2,046,840; 2,082,085; 2,084,078; 2,084,079; 2,090,338

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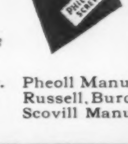

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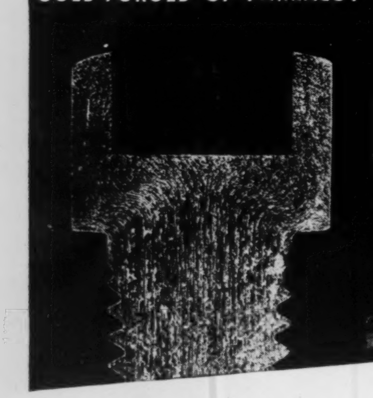

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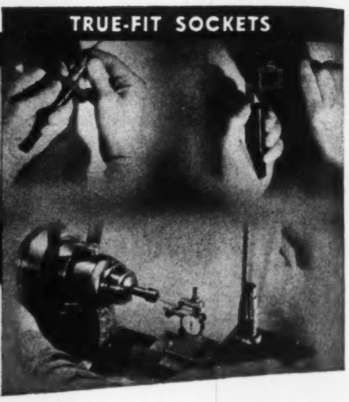

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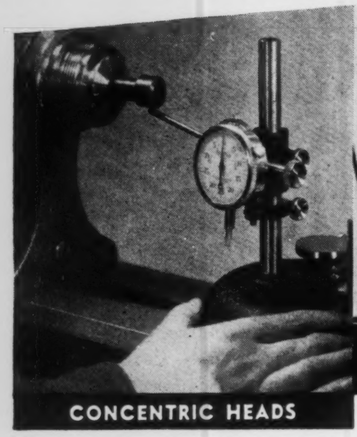

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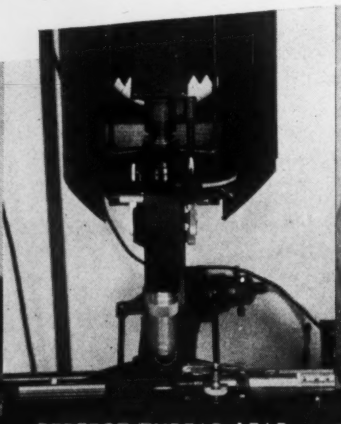

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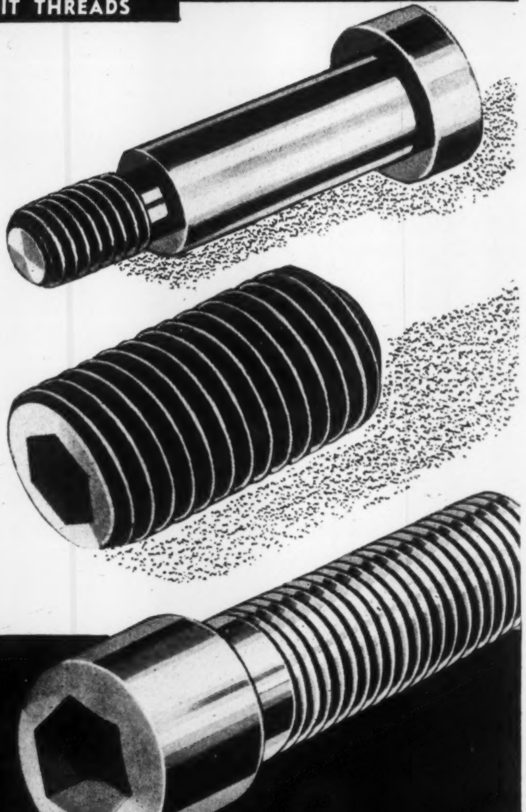

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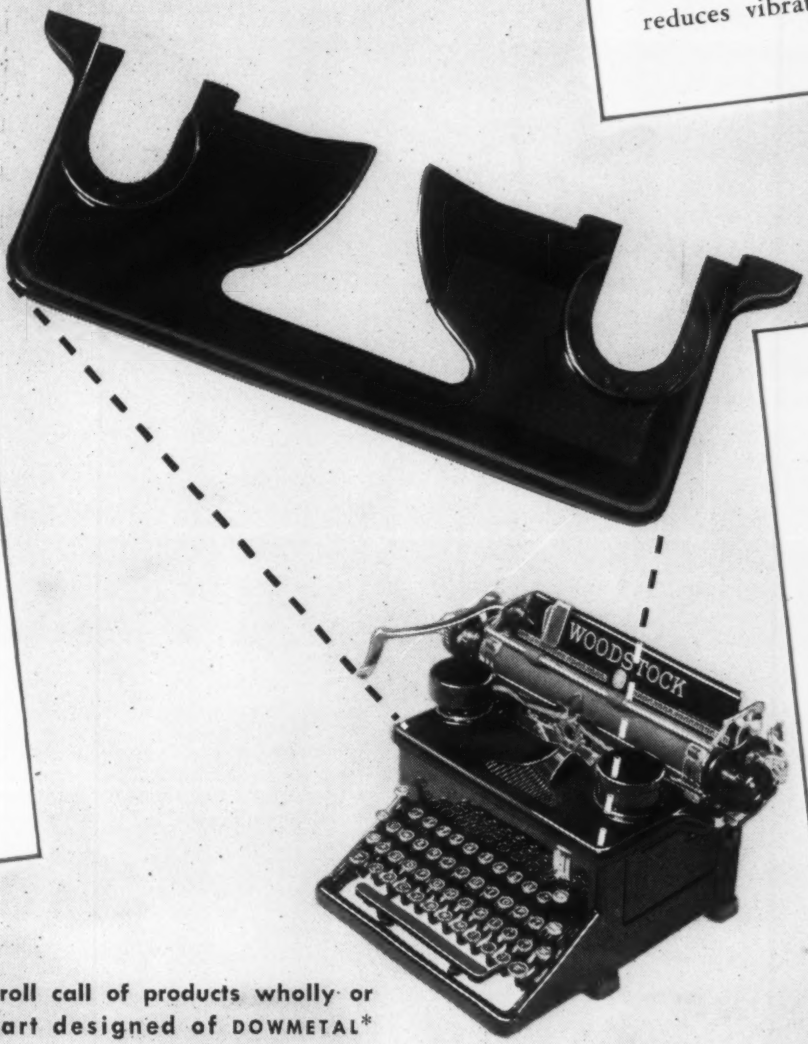

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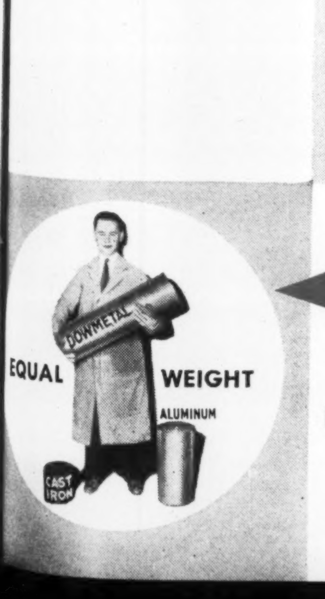

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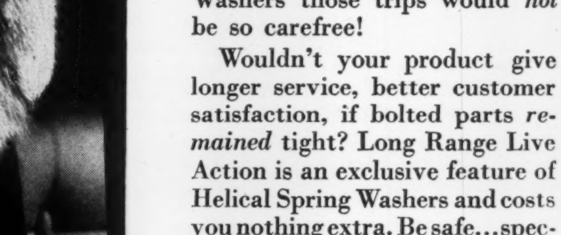

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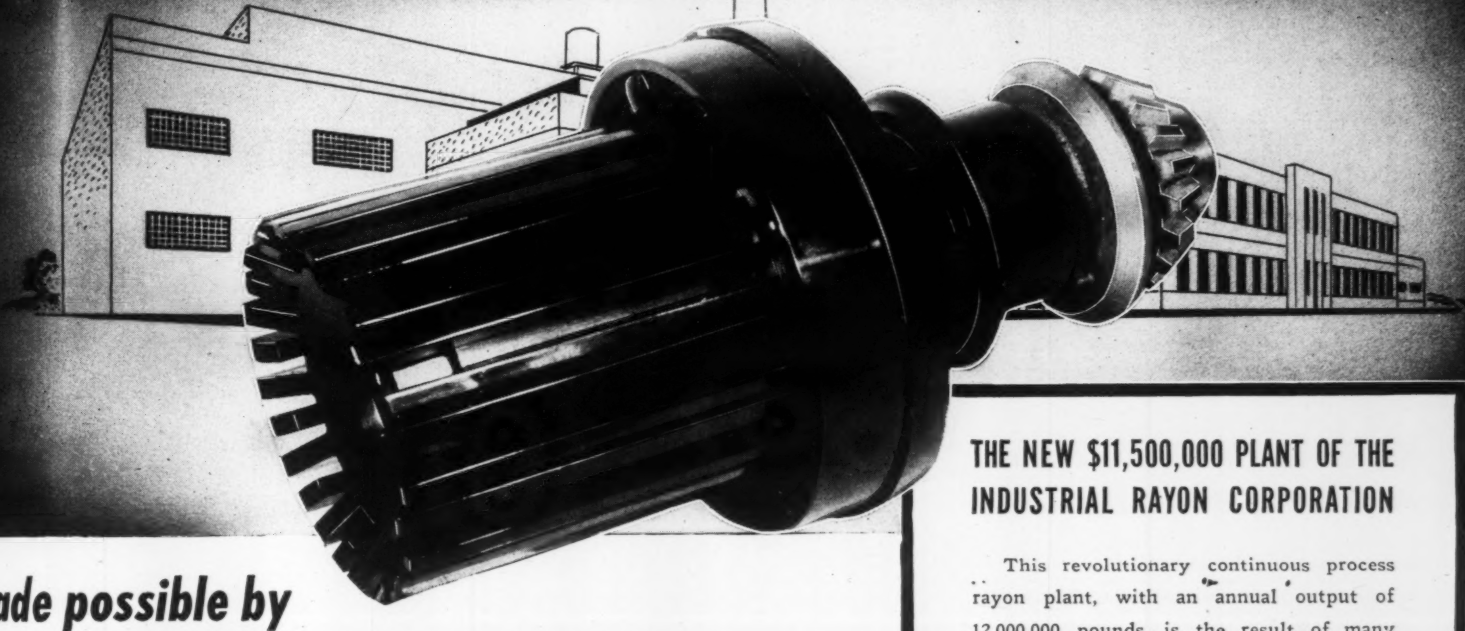

THE NEW $11,500,000 PLANT OF THE INDUSTRIAL RAYON CORPORATION

This revolutionary continuous process rayon plant, with an annual output of 12,000,000 pounds, is the result of many years of experimental and developmental work. Perfected by Rayon Machinery Corporation, wholly owned subsidiary of Industrial Rayon Corporation, this process was made possible by the molded plastic members of the reel.

Richardson engineers, designers and plastics technicians are proud to have had an active part in writing this new epoch-making chapter in the history of the rayon industry.

made possible by *the* PLASTIC SPINNING REEL Precision Molded *by* Richardson

n Painesville, Ohio, stands the world's rst plant for the continuous producion of viscose rayon yarns. There a uccession of chemically resistant lastic reels of ingenious, highly-deeloped design, make it possible to arry rayon yarn from the spin bath here it is formed, through all the rocessing, cleansing, drying and twistg operations to plastic bobbins on hich it is first wound up.

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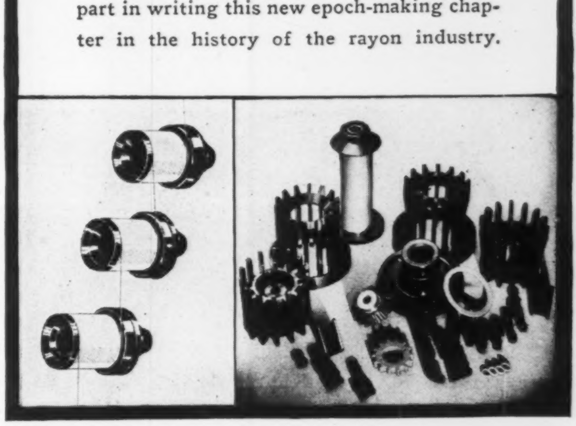
Heart of the continuous process is the plastic spinning reel, developed with Richardson collaboration from complex experimental models to a simple precision molded composite reel. In addition, numerous other Richardson molded and laminated plastics are widely used—jet unions; thread guide holders and brackets; INSUROK laminated gears and seal rings; bobbins and other parts—because of their unvarying physical characteristics and resistance to all spinning and processing liquors.



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the superior plastic by Richardson, is available in sheets, rods, tubes, punchings, and other forms for fabrication in your plant, or in completely finished parts ready for assembly. Richardson facilities encompass the use of Bakelite, Beetle, Durez, Indur, Plaskon, Resinox, Tenite and other forms of synthetic resin plastics. Literature and INSUROK catalogues on request.

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Topics

TWO recent aeronautical events which blazed into the nation's headlines have broad significance for designers. First and most sensational was the experimental transcontinental flight of the new Lockheed substratosphere plane from March field, Calif., to Mitchel field, L. I., where it crashed on landing. This is the ship, powered by two 1000-horsepower Allison liquid-cooled V-12 engines, which was said by conservative Army Air Corps officials to have approached 400 miles per hour. Its most startling characteristic—its "in-line" cylinder arrangement—constitutes the answer to its tremendous speed. Aeronautical authorities in this country have contended for years that the physical limit of speed with the radial type aircooled engine has just about been reached. European plane builders have advanced far with "in-line" engines mounted directly in front of the wings. Perfect streamlining can be attained, so that any further speed will depend on greater engine power; and for military planes, straight-line power plants form a perfect, rigid mounting for guns. Second notable event was the nonstop transcontinental flight of an 800-pound two-seater Aeronca "Chief." No speed records were set, inasmuch as the flight took 30 hours 47 minutes. But the small plane's flight, in fuel and oil, cost only $25.70, virtually the cheapest rate of cross-country travel. Light weight in the engine can be attributed in part to aluminum-nickel alloy for cylinder heads, cadmium-nickel alloy for connecting rod and crankshaft bearings, nickel alloy steel for crankshaft, gears, rocker arms, studs and other stressed parts.

◆

THERE'S nothing new in the use of rubber to attain additional comfort and safety in automobiles, but it's remarkable to realize, as Chrysler Corp. points out, that rubber's utilization has increased to the point where around 300 pieces in one form or another go into cars. After years of cushioning engines, bodies, and front and rear suspensions, rubber is being used to prevent ingress of wind, snow and rain, and to prevent squeaks by grommeting parts where controls enter the car body. Nor should the development with the most revolutionary potentialities be forgotten: Foamy latex for seats and other purposes.

◆

GREATLY increased opacity has been attained in porcelain enamel finishes. Although applied in a coating 40 per cent thinner than that required formerly, the new enamels are said to have equal covering power. Other claimed advantages: Increased resistance to mechanical shock and deflections, greater resistance to scratching, virtual elimination of chipping, and the capacity for being sheared neatly without chipping from the edges. An authority in the finishing field points out that enamel finishes which bake rapidly at high temperatures, thus helping production speed, are becoming increasingly popular. There are limits to the use of such finishes, however. Short baking schedules at very high temperatures cannot be controlled closely enough to give uniform results. Best practice appears to be adoption of a schedule combining speed with dependability. Progress also has been made in improving durability of finishes for withstanding action of humidity and household chemicals, and in the development of transparent colored coatings which reproduce colorings of various metals and platings.

◆

AT THE 150th meeting last week of the American Institute of Mining and Metallurgical Engineers, Dr. H. W. Gillett, Battelle Memorial institute, Columbus, O., reported new work on metals under stress, of interest particularly to designers concerned with creep of steel under heat and steam pressure. Dr. Gillett heated steel strips in special furnaces and simulated the conditions produced in boilers by attaching weights to the strips. Some of the strips expanded one six-millionth of an inch for each inch of length. A 2-foot steel bar thus would creep more than 1/10,000-inch. Since rearmament is a burning subject at present, the U. S. Navy is among the groups most interested in research of this kind. Some men in the department are in favor of equipping new battleships with boilers using steam at unusually high temperatures. Others maintain the steel now available won't stand the strain.

The Day of JACK-OF-ALL-TRADES is Past

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And in the particular branch of power transmission engineering devoted to *variable speed control* that fact becomes constantly more apparent.

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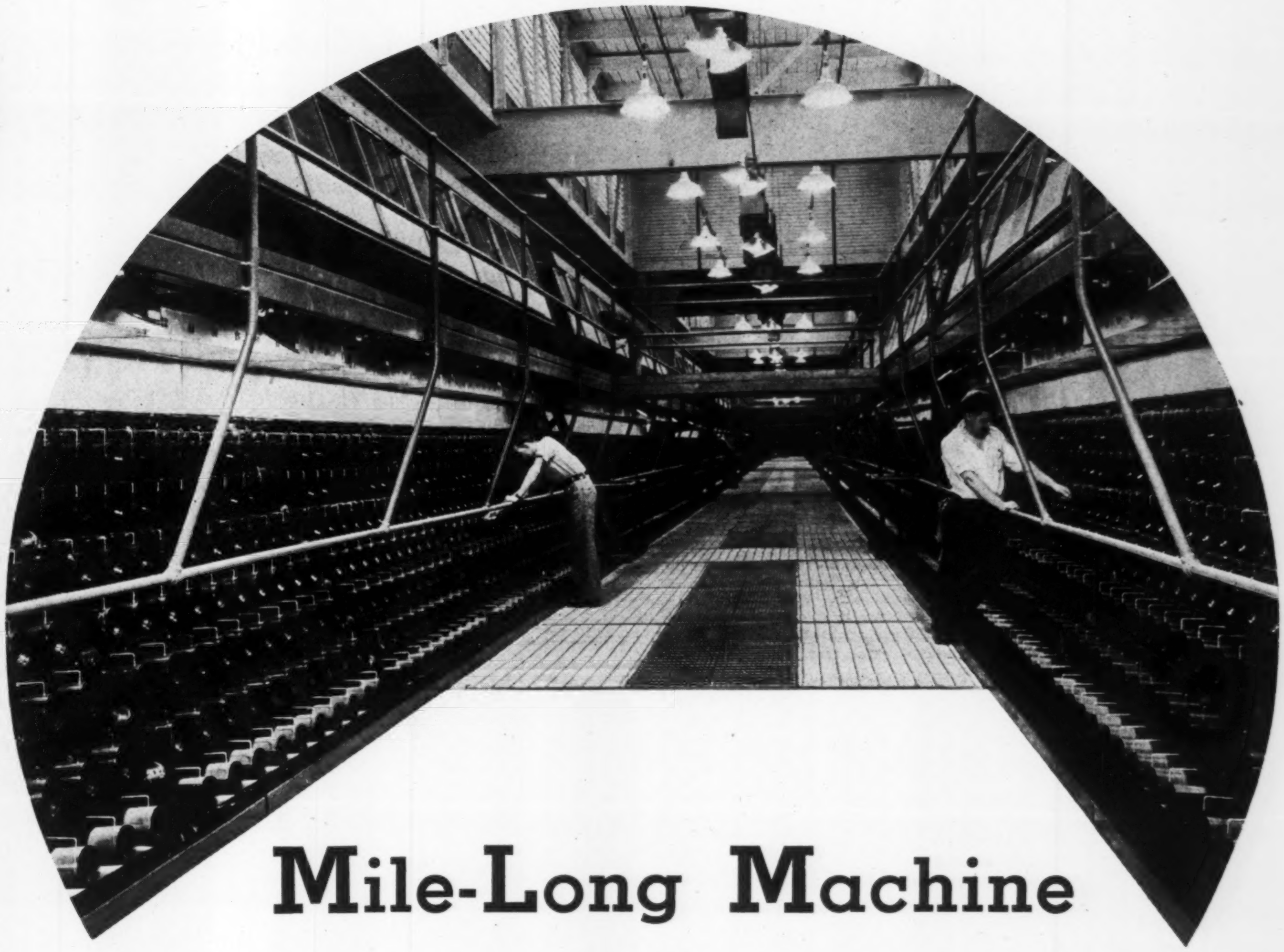


Mile-Long Machine Performs Continuous Process

By R. F. Bergmann

Chief Engineer,
Rayon Machinery Corporation

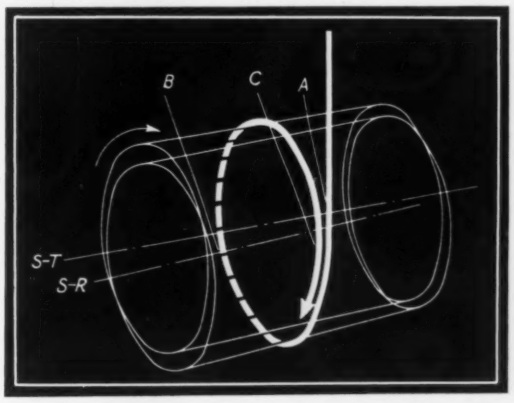
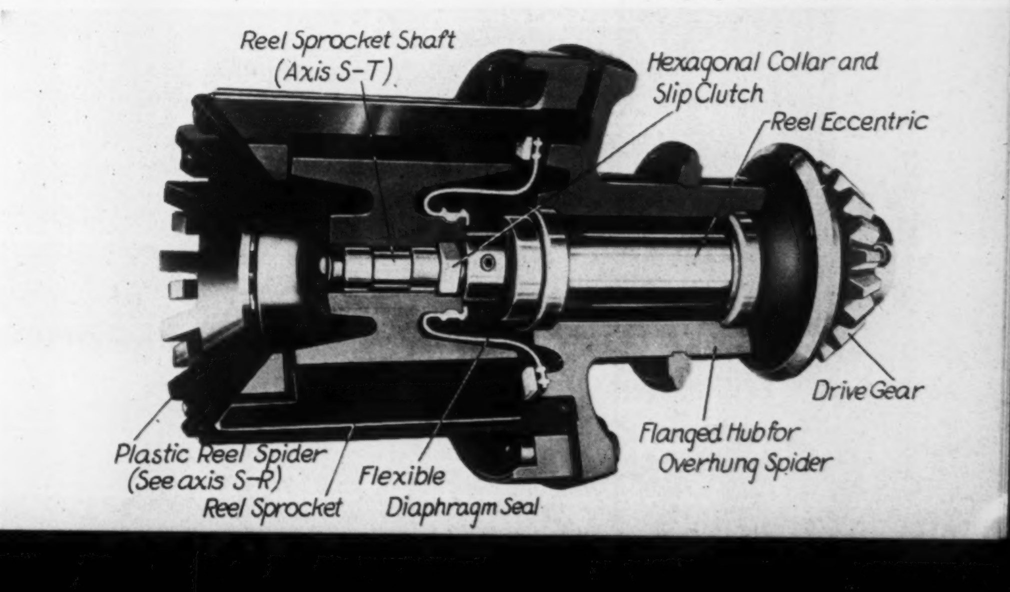


Fig. 1—Above—Second tier of the plant, on which are located the process reels. Fig. 2—Left—Principle of operation of processing, drying spin, reels. Fig. 3—Below—Assembly of parts of the processing reel, principal members being plastic

Photograph courtesy Richardson Co.



Reel Sprocket Shaft
(Axis S-T)
Hexagonal Collar and
Slip Clutch
Reel Eccentric
Drive Gear
Flanged Hub for
Overhung Spider
Plastic Reel Spider
(See axis S-R)
Reel Sprocket
Flexible
Diaphragm Seal

DEVELOPMENT and standardization of the continuous viscose rayon spinning and processing machines recently placed in operation at the Industrial Rayon Corp.'s new Painesville, O., plant presented many challenging problems which had to be solved before machines could be built and the plant equipped on a practical, commercial basis.

Without the availability of

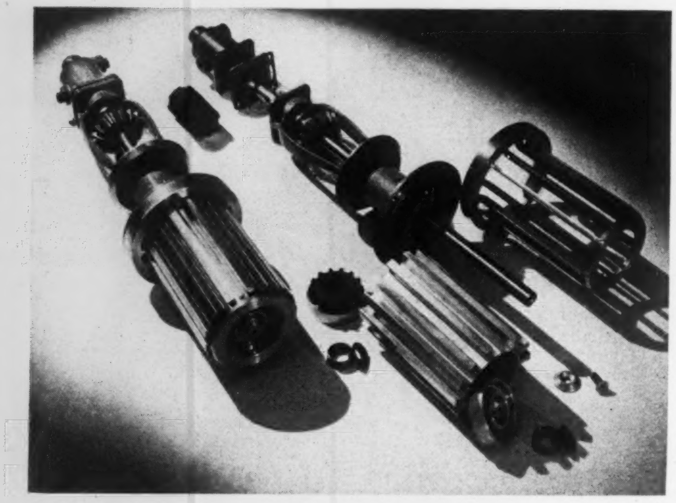


Fig. 4—**Aluminum drying reel, assembled and disassembled. Principle of thread advancing on this reel is the same as on the plastic process reel, but several other aspects of its design are different**

modern materials and methods the solution of these problems would not have been possible. The continuous rayon process, revolutionary in itself, depends on plastics, molded hard rubber, arc welding, extruded aluminum, permanent mold castings and forgings, sealed ball bearings and oilless bronze bushings, and unique drive mechanisms.

After preparation of liquid rayon or viscose by dissolving cellulose fiber sheets in a series of controlled chemical baths, the operations performed by the machines, of which 96, or 48 pairs are installed, include the following:

> Spinning separate filaments of the yarn by forcing the viscose through minute holes of a jet or spinneret submerged in an acid bath in lead-lined, glass-enclosed spin tanks at the top of each machine.
>
> Processing treatments, comprising washing, desulphuring, bleaching, lubricating, drying and twisting on to bobbins. Yarn is given these treatments while rotating on reels arranged in tiers, as shown in *Fig.* 1.

The key to the process is the continuous treatment of the yarn until it reaches its final finished form. In turn, this successive treatment is made possible by the design of the unusual thread-advancing reel illustrated in *Fig.* 3.

Fig. 2 shows schematically the principle of the reel's operation. Assembly of parts of the reel is revealed in cutaway in *Fig.* 3. Disassembled parts are laid out in *Fig.* 4. Finally, the drawing of a reel in *Fig.* 5 shows the design in detail.

It will be seen that two kinds of reels, each employing the same principle of thread-advancing, are used. The reel in *Fig.* 3 is the processing reel, the principal members of which are molded of plastic. The drying reel in *Fig.* 4 and 5 has similar parts but made of aluminum extrusions and permanent mold castings.

To obtain the thread advancing action of the reels (described later) two slat pulleys, (a reel sprocket and an overhung reel spider) set one within the other, revolve together as an overhung assembly. These when in motion, assume the appearance of a single cylinder. They do not, however, revolve about the same center.

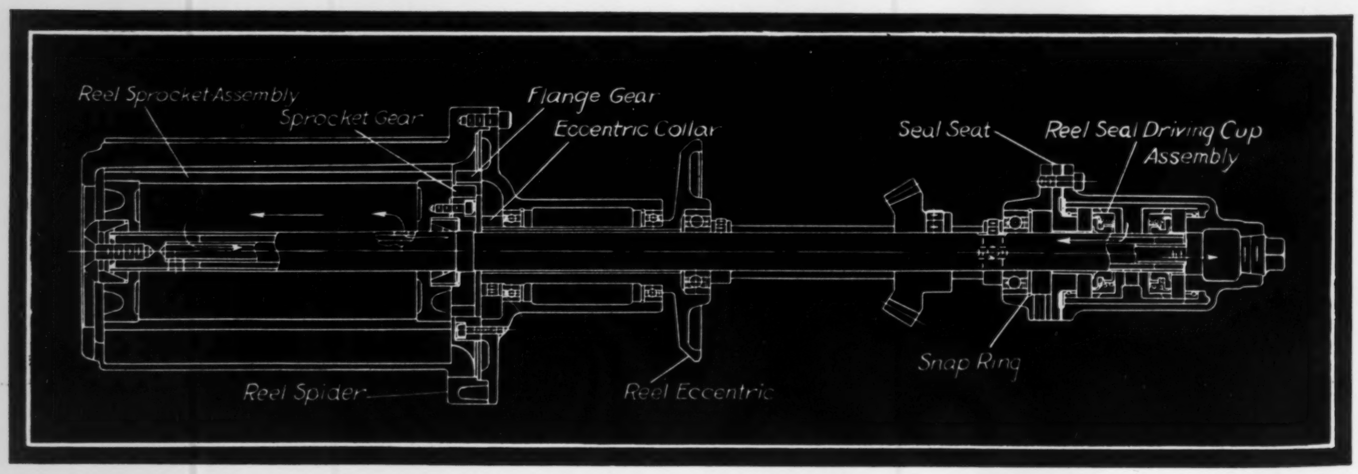
Rotation Comes Through Sprocket

Actual rotation comes through the reel "sprocket," indicated by axis S-T in *Figs.* 2 and 3, driven by the cut plastic bevel gear at the right of *Fig.* 3. The drive shaft may be seen in the cutaway picture, as well as a hexagonal metal insert in the sprocket, which embodies an overload slip clutch. The sprocket is bronze bushed and capped on its front end. A flexible diaphragm protects all reel bearings from process solutions.

The overhung reel spider's axis is indicated by axis S-R in *Fig.* 2. This not only is off center but is skewed in order to impart a spiral winding to the yarn. In *Fig.* 3 may be seen the flanged hub for the spider, mounted on sealed ball bearings and set eccentrically. The spider rotates on this flanged eccentric, and is driven by the contact of its bars with the bars of the sprocket, with which it is nested in the assembled reel.

As indicated previously, the purpose of this ingeni-

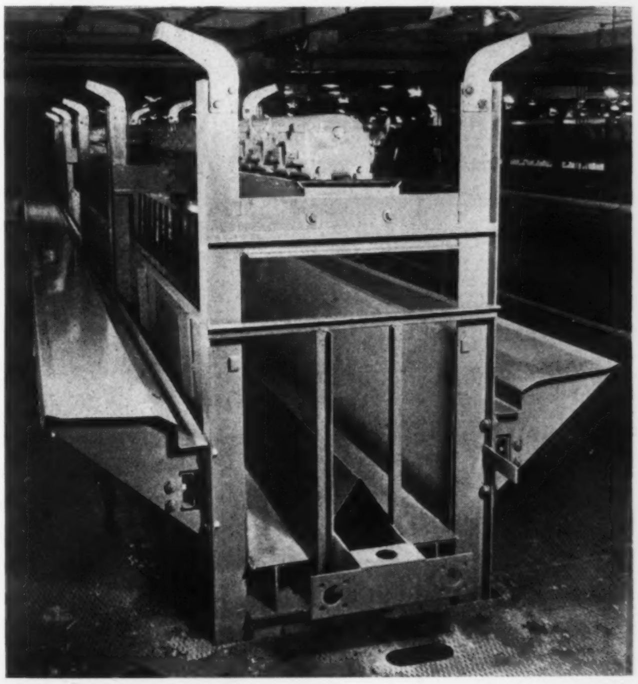
Fig. 5—**Cross-sectional diagram of the dryer reel, made of aluminum because of that metal's chemical characteristics, conductivity and ability to withstand drying temperatures. Arrows indicate internal path of water**



ous eccentric-skewed design is to enable the yarn to start revolving at the inboard end of the reel and move continuously and evenly to the outer edge (left in the illustration).

Yarn led on to the reel at point *A*, *Fig.* 2, travels around the bars of the lower pulley (axis S-R—the spider) for approximately one-half turn to point *B*. There it transfers to the bars of the upper pulley (axis S-T—the sprocket) and travels for another half turn to point *C*. By this time it has gone one complete turn around the reel, and because of the eccentric-skew of the spider the yarn has advanced a given distance toward the end (left) of the reel. The degree of skew controls the spacing or number of turns per inch of yarn on reel. At point *C* the yarn again transfers to the bars of the lower pulley (the spider) and successively goes through this rotation until it reaches the end of the reel and is passed to another reel below.

Mechanical design of these reels was a highly important factor in the success of the machine as a whole, but choice of material for reels was also vital. The yarn during processing is subjected to warm dilute sulphuric acid, desulphurizing and bleaching solutions, hot wash waters and emulsions for lubricating. Since these liquids are poured on the yarn in motion, the reels had to be chemically resistant for indefinite periods without dimensional changes.



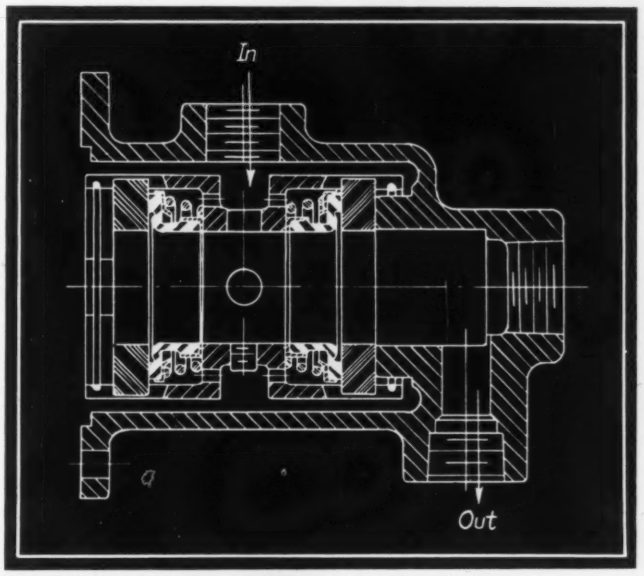
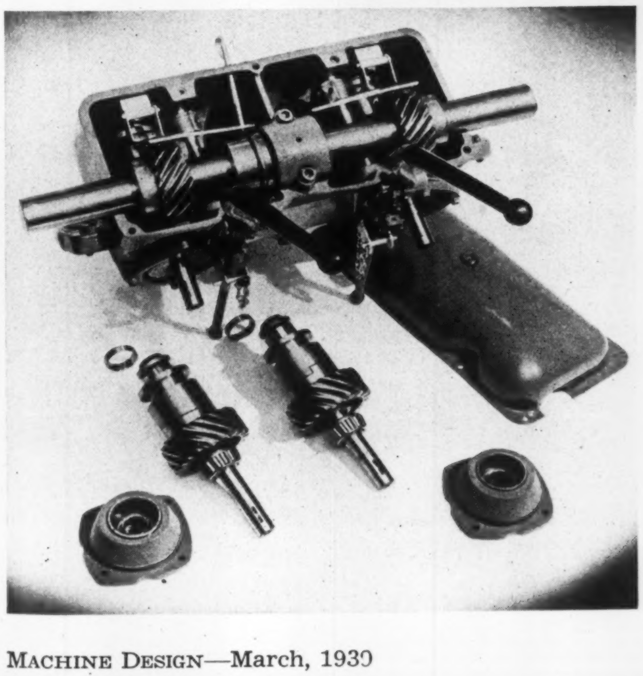


Fig. 7 — Left — Seal assembly for dryer reel, showing where water enters and leaves housing. Fig. 8—Above—Top tier of spinning machine before installation of sheet lead covering trough and ventilated hood. Here rayon is extruded into acid bath and wound on spin reels

Fig. 6 — Below — Process reel gear box with top removed. The two right-angle take-off shafts are coupled to inclined bevel gear shafts behind the process panels in Fig. 10. This box may be clutched off the drive shaft and lifted out without shutting down any positions except the two served by its own output shafts



Plastics, accurately molded and machined, were finally chosen for the process reel members. All plastic reel parts are interchangeable in dimensions, and may be assembled with eccentrics which will provide yarn spacing used on any of the nine stages.

The drying reel is shown in *Fig.* 4, assembled and disassembled, and in *Fig.* 5. This reel operates on the same principle as the plastic process reel, but is changed in several other aspects of its design. By the time the yarn reaches this reel it has gone through its treatment and must be dried before being twisted on to bobbins. Aluminum was chosen for the reel's material because of its chemical characteristics, conductivity and ability to withstand drying temperatures. The reel sprockets are hollow aluminum extrusions. Blanks from these extrusions, counterbored and plugged on each end with finished forged aluminum heads, provide a practical, dependable water-jacketed medium for drying the yarn.

For drying purposes hot water is passed through the reel and out again, the arrows in *Fig.* 5 showing the path of the water. In *Fig.* 7, showing the seal assembly for the dryer reel, a portion of the water's course also may be seen. The water enters the housing, travels to the other end of the reel, and returns through the center tube to the housing. Actually, in *Fig.* 5 the inlet is on the far side.

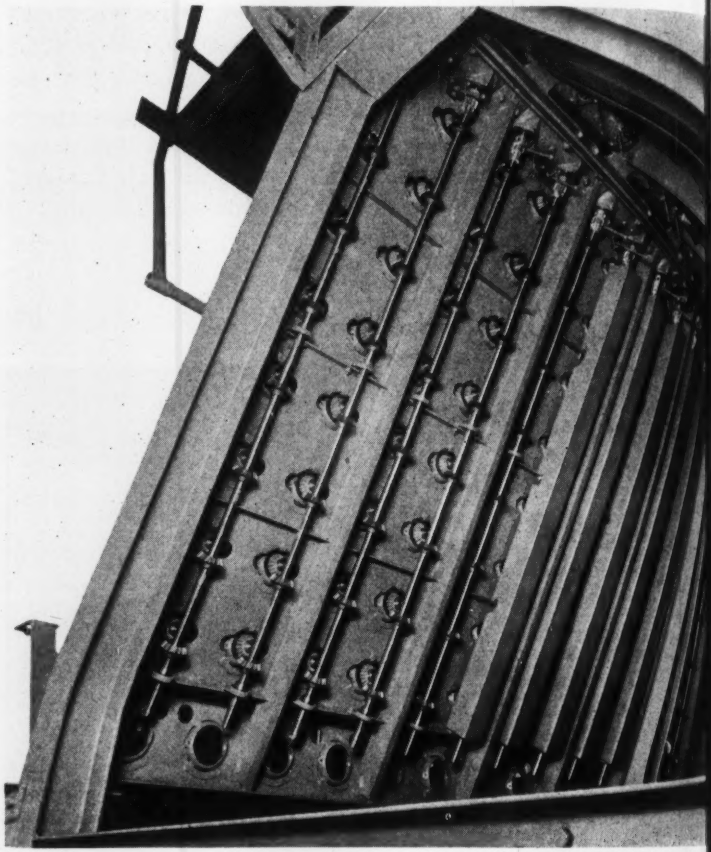
Welded Construction Found Best

Before discussing the transmissions which drive the process and spinning reels, mention should be made of the general appearance and construction of the machine (actually, of course, 96 separate but co-ordinated units). Preliminary studies revealed that fabricated and welded steel construction offered the greatest possibilities for this machine. The most logical arrangement for combining the rayon spinning and processing stages was to tier them, thus gaining compactness, saving floor space and providing ease of threading when starting or resuming operations on any position.

An A-shaped structure, symmetrical about a vertical center line and with three operating levels was developed, the second level being shown in *Fig.* 1. Despite considerable skepticism, jig welding was employed in joining the assembly. Easily obtainable, rolled structural steel sections were used wherever possible.

It was desired to avoid any machining of surfaces after the assembly was welded and removed from the jigs. This was eliminated by the extensive use of flanged bearing housings and adjustably mounted transmissions, aligned and doweled on erection.

Fig. 8 shows the top of spinning machine before installation of the sheet lead covering trough and venti-



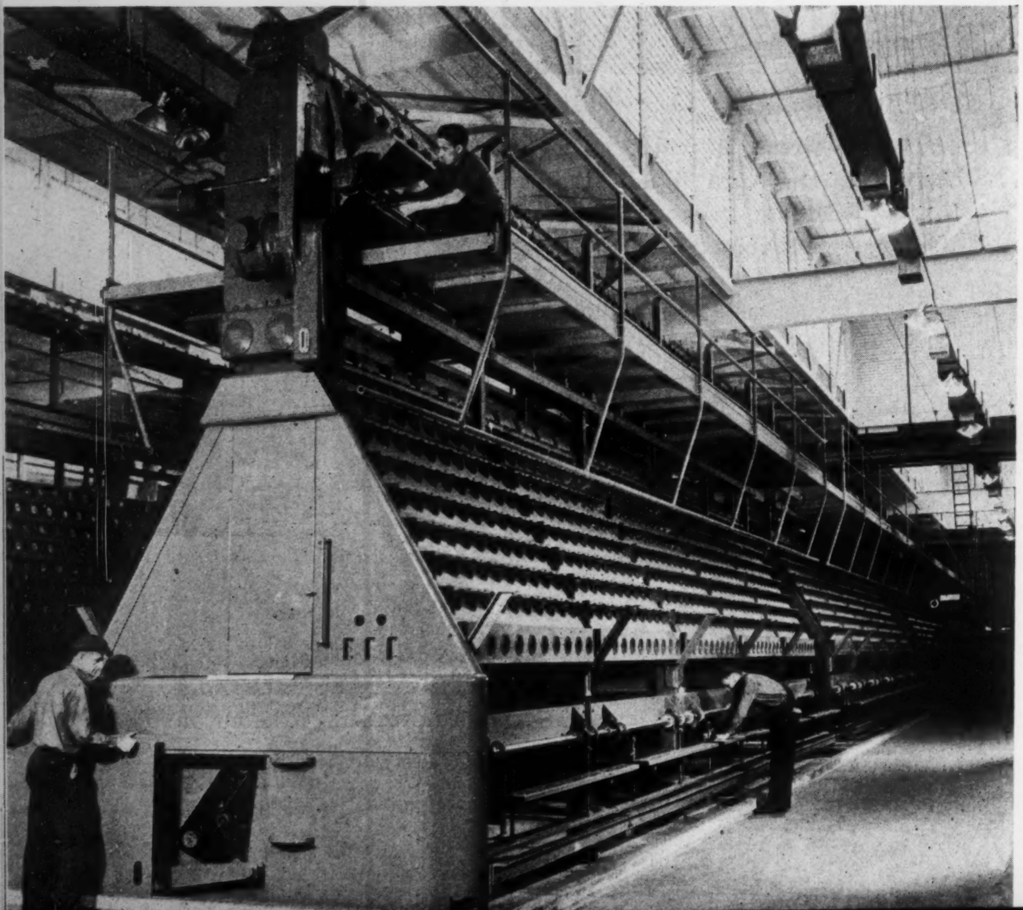
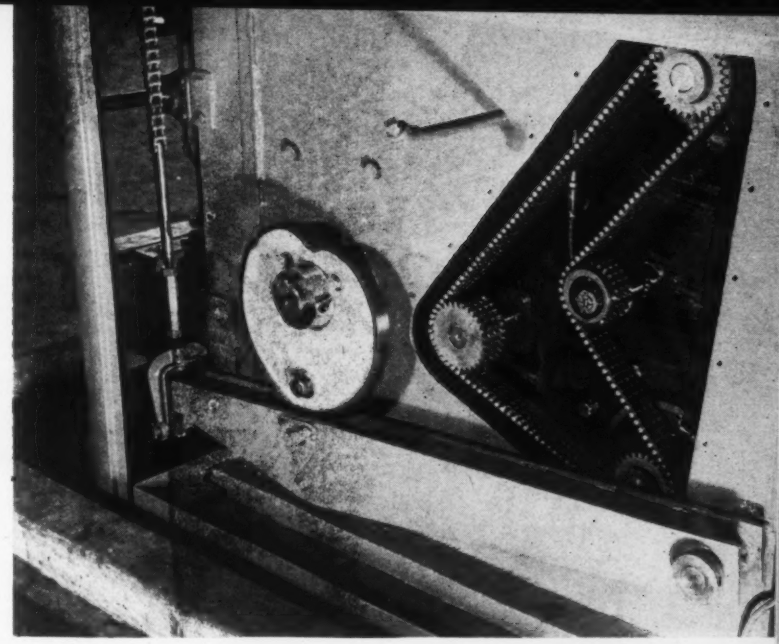
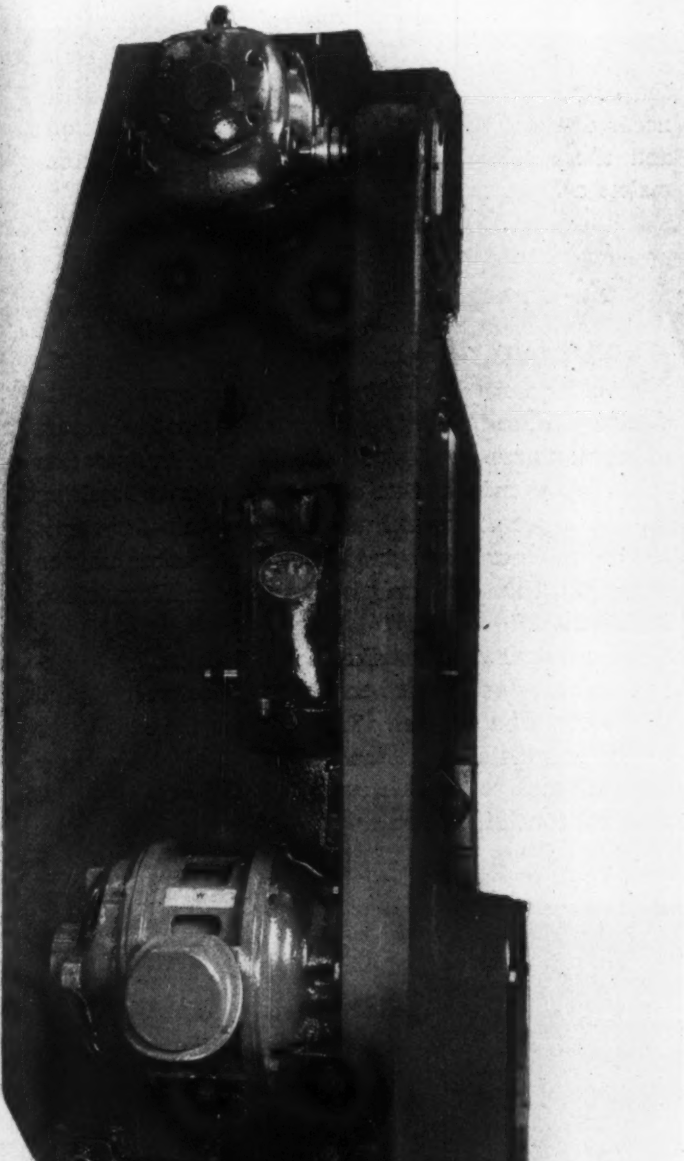


Fig. 9—Left—View of lower tier showing twister tables, grouped in series of five, which twist yarn on bobbins. Workman at left is fitting panel over cam mechanism and duplex silent chain drive. Tables are counterweighted and suspended by pulleys and shafts on each side of the machine. See Fig. 11 for more complete picture of cam mechanism. Fig. 10—Above—Behind the process panels where gears on the inclined shafts drive the nonmetallic gears on the process reels

Fig. 11—Right—Cam mechanism for twister tables is totally enclosed and chain tensions are maintained by spring-backed automatic idlers. Force feed lubrication from an oil sump in the bottom of each casing is provided for all chain drives. Fig. 12—Below—Drive unit for the spin and process reels. At top is a worm drive, output shaft of which is extended through the spin reel transmissions shown in Fig. 8. At bottom is a worm gear shaft with two output shafts, each coupled to a longitudinal drive shaft extending through the process reel gear boxes on the second tier





lated hood. Here the rayon is extruded into the acid bath and first wound on spin reels driven by the gear box units shown. Catwalks for operators are cantilevered from the frame members.

The drive unit for the spin and process reels is shown in *Fig.* 12. At the top is a worm drive, the output shaft of which is extended through all the spin reel transmissions shown in *Fig.* 8. At the bottom is a worm gear drive with two output shafts, each coupled to a longitudinal drive shaft which extends through the process reel gear boxes on top of the stepped, welded process panels on the second tier.

Box Has Two Take-Off Shafts

Fig. 6 shows one of these transmission units. Each box has two right angle take-off shafts, which are coupled to inclined bevel gear shafts behind the process panels as can be seen in *Fig.* 10. Gears on the inclined shafts drive the self-lubricating plastic gears on the process reels. Each of the spiral driven gears in the transmission engages with a splined spiral clutch, which may be shifted to clutch out the line of reels driven by the inclined bevel gear shaft to which the output shaft of the gear box is coupled.

An interesting feature of the process transmission is the fact that it may be completely removed from the machine for servicing and re-installed without shutting down any positions except the two served by its own output shafts. After removing the cover, clutch levers and through shaft bearing cap, the entire box may be lifted out over this shaft and removed. Similar provision has been made for servicing individual elements on all other stages of the machine, so that it is never necessary to cut out of production more than one or two spinning and processing positions, out of the total of 100 provided.

Final stage of the machine's operation, the twisting of yarn on bobbins, involves the totally enclosed duplex silent chain drive and the cam mechanism in *Fig.* 11.

(*Concluded on Page* 41)

Scanning THE FIELD FOR *Ideas*

Unique Diesel Has Variable Stroke

TWO horizontal and opposed pistons transform power directly into compressed air energy in a two-cycle diesel engine designed by the French firm, Breguet. According to Alfred Wasbauer, consulting engineer, there is no mechanical intervention other than a rigid connection between the diesel pistons and compressor pistons. Travel of the opposed pistons is synchronized by a pair of connecting rods joined to a double-end rocker arm as shown in *Fig.* 1.

A unique feature of the compressor, besides the absence of crankshaft and rotating members, is the variable stroke of the pistons determined by the amount of fuel injected into the diesel cylinder. When the fuel is reduced to the point where there is no compressed air discharge, the compressor idles. Naturally, it is always the compressed air remaining in the air cylinders which sends the pistons on their return course. This novel mode of operation results in high efficiency, particularly at high altitudes.

Actuated by the expenditure of air, an automatic governor acts directly on the fuel pump to regulate the course distance of the pistons according to the needs of the moment. Perfect balance of the pistons and the absence of transmittable rotative stresses makes a light construction possible.

Self-Contained Telephone System

OBTAINING its power solely from the speaker's voice, a newly designed telephone generates its electrical voice-transmitting current from the impact of sound waves on a special diaphragm. Its operation is therefore independent of external power, making the unit especially useful where self-contained systems are desirable or where independent operation may be required. This unit, designed by Western Electric Co., is shown in *Fig.* 2.

When sound waves strike the diaphragm, an armature vibrates and varies the air gaps between it and pole pieces of a magnet. This changes the reluctance of the magnetic circuit and induces voice frequency currents in a coil which surrounds the armature but does not touch it. Conversely, when voice currents are

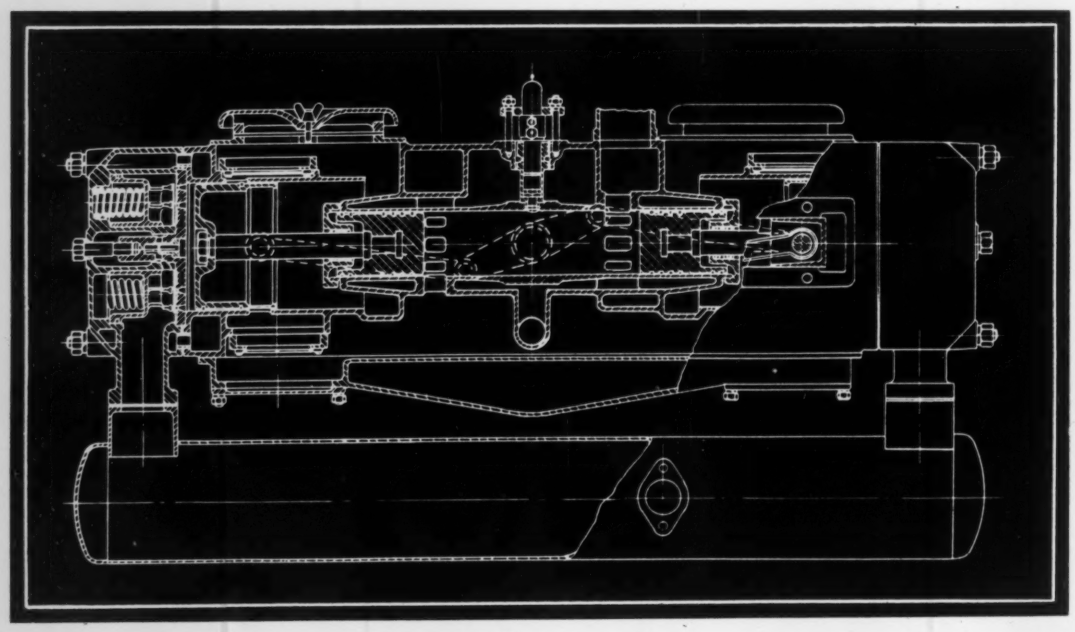


Fig. 1—Variable stroke diesel using balanced, opposed pistons is integral with air compressor

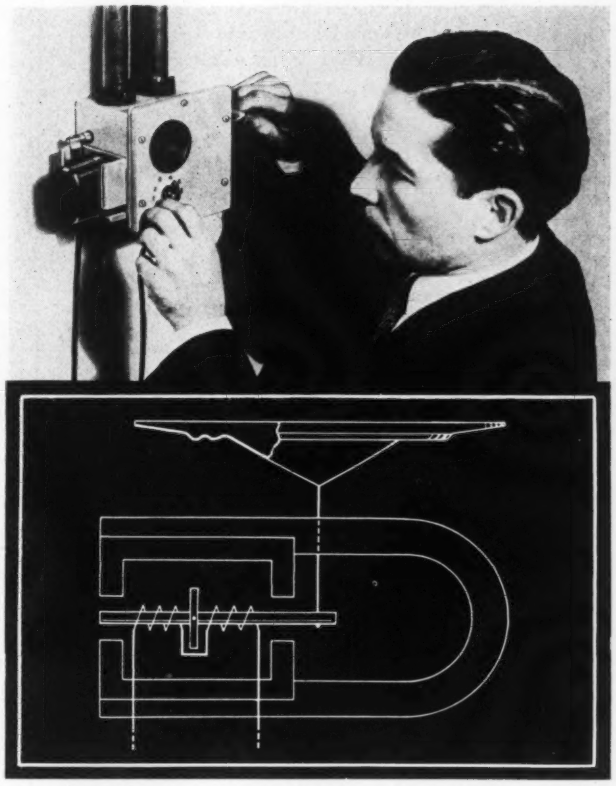


Fig. 2—Voice produces power for telephone. Blueprint shows how diaphragm generates current

imposed on the coil, the armature and diaphragm vibrate and reproduce speech. In this way the single instrument serves alternately as transmitter and receiver.

Signaling current is generated at any station by a hand-operated generator to create an audio frequency current by rapidly varying the reluctance of the magnetic circuit. Two disks with teeth of magnetic material are so placed with respect to the armature and magnet that their rotation generates alternating current of about 1,000 cycles per second. Removing the receiver from the hook transfers the telephone from a signaling to a talking circuit.

Duralumin is used for the cone-shaped diaphragm. To obtain an efficient magnetic circuit with small, lightweight parts, a magnet of remalloy is utilized. Pole pieces, armature and teeth of the rotors are permalloy, the teeth themselves being separated by nonmagnetic material to reduce leakage.

Tungsten Grains Dampen Bounce

WHERE it is desirable to dampen vibrations without a mechanical lock-in device for delicate mechanisms such as contacts used in sensitive relays, an important principle of energy absorption has been applied. Without damping features, contact arms would bounce repeatedly in absorbing the energy of impact. To remedy this critical fault, non-bounce contacts have been developed that contain a hollow capsule partially filled with fine grains of tungsten.

In operation, such contacts make positive connection immediately on closing. All the energy is dissipated within the capsule by interfriction between the heavy grains of tungsten. High speed oscillographs have shown no indication of separation following initial closure during tests.

Concave Members Actuate Switch

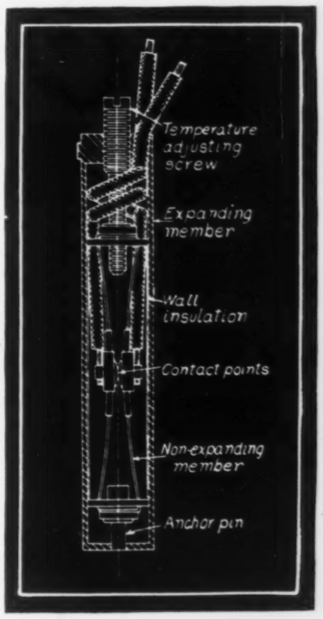
THE principle of thermal expansion of an enclosing shell to separate electrical contacts on thermally inert members has been applied by Fenwal, Inc. in the form of a unique thermo-responsive electric switch. This unusual design is shown in *Fig.* 3.

The switch has a sensitivity of ± 1/10 degree Fahr. with no themal lag. Reference to the illustration shows the thermo-responsive element is an outer brass shell enveloping the entire unit. Silver contacts are affixed to the electrical leads and mounted upon bi-concave compression members of thermally inert metal. These members press the contacts together firmly while they are closed.

A calibrated adjusting screw in the head puts an initial stress on the members so that, when the shell is extended by heat, the contacts are pulled apart at a predetermined setting. An inverse type has also been designed in which the members are convex so that heating forces the contacts together to complete the electrical circuit.

Movement of the contacts is slow break, yet their separation is approximately 20 times the expansion of the shell. Therefore make-and-break are definite with small changes of temperature. Sputtering due to vibration of contacts has been eliminated because the force necessary to overcome contact pressure is great enough to prevent vibration.

Fig. 3—Thermal switch is enclosed within active element. High sensitivity is assured by novel construction



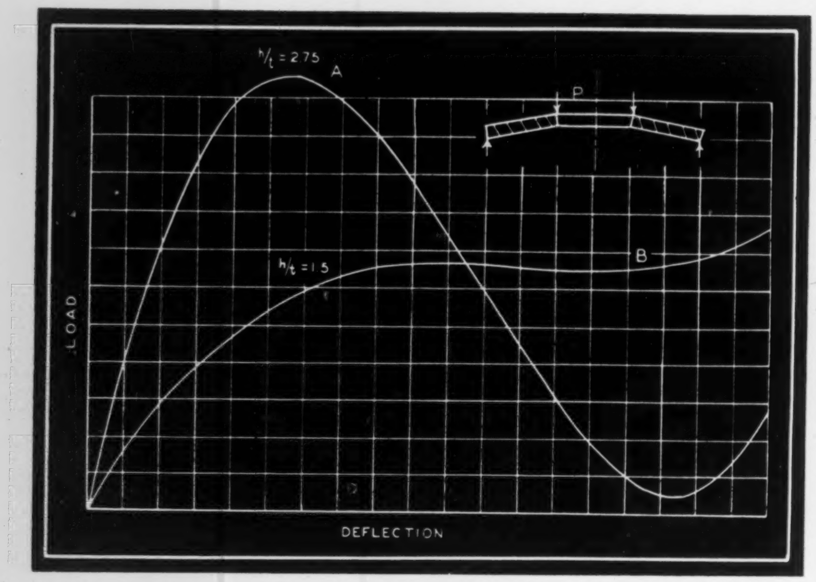


Fig. 1—Curves in chart illustrate two types of characteristics obtainable with disk springs

Design an
Dis

By A. M. Wahl

MANY spring applications require nonlinear load deflection characteristics of various forms. Such characteristics are useful in design and may be obtained with initially coned disk springs, commonly called Belleville springs. Often springs having approximately zero rate over a limited range and those having buckling characteristics are desired and may be obtained by varying the ratio of initial cone height to disk thickness.

Design of these springs is discussed in this article together with charts and formulas for facilitating practical application of stress and deflection equations as developed at Westinghouse Research Laboratories. For given proportions, deflections for varying loads may be determined from the curves. Also discussed are designs of initially flat, radially tapered disk springs. Numerical examples illustrate practical applications of equations and curves.

Design of Belleville Springs

In certain cases a load characteristic of the shape shown in curve *B* of *Fig.* 1, which has a load deflection rate of approximately zero over a considerable range of deflection, may be desirable. Other applications may require the type of characteristic indicated in curve *A*. Both of these types, as well as a wide variety of intermediate shapes, may be obtained by using initially coned disk springs of uniform thickness. Changes in the shape of the curve are effected by varying the ratio of cone height h to disk thickness t as shown in *Fig.* 2. Thus, in *Fig.* 1, curve *A* is obtained for a ratio $h/t = 2.75$ and curve *B* for a ratio $h/t = 1.5$.

Where space is limited in the direction of load application, use may be made of Belleville springs or radially tapered disk springs. The latter springs have a thickness proportional to the radius, as shown in *Fig.* 3, and may be found advantageous. An application of this type of spring in the design of motor commutators is illustrated in *Fig.* 4. The main advantage of a radially tapered disk spring is that the stress is practically constant along the radius, whereas in the Belleville type of spring the radial stress distribution is nonuniform. Therefore more energy may be stored in a given volume of material for the same maximum stress in a radially tapered disk.

An exact mathematical solution of the stresses and deflections, *Fig.* 1, in a Belleville spring under given loads is extremely complicated. It is, however, possible to obtain an approximate solution to this problem by

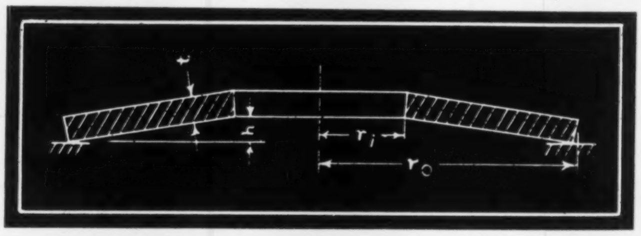


Fig. 2—Above—Belleville spring. Fig. 3—Below—Radially tapered disk spring. Symbols used in formulas are indicated

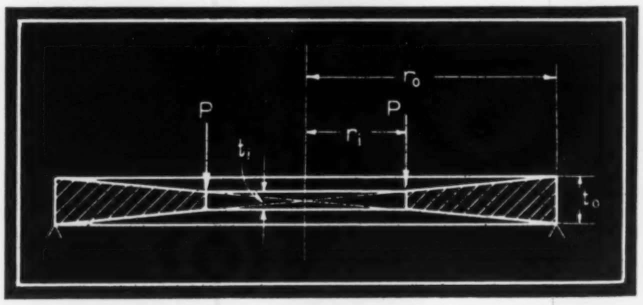
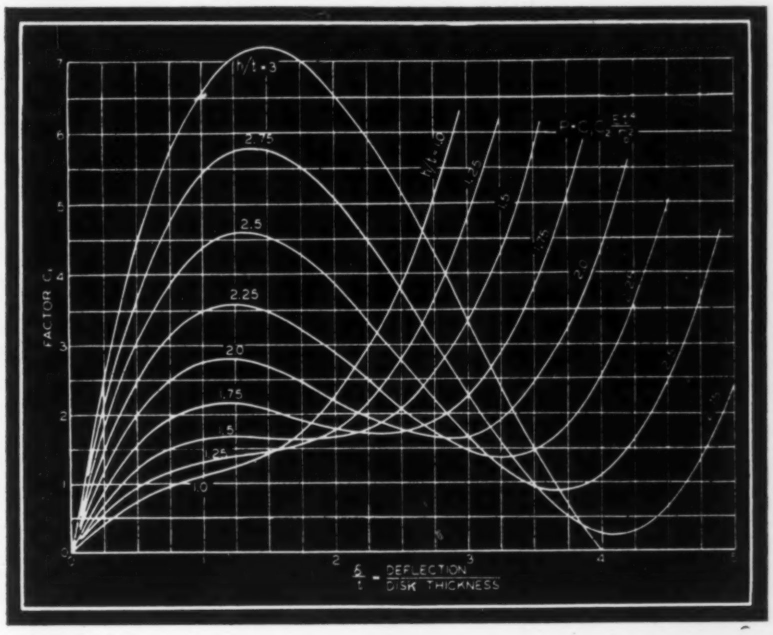


Fig. 5—Curves for determining deflection factor C_1 for Belleville springs



an Selection of is Springs

assuming that the dish angle is small and that under deflection radial cross sections of the spring rotate without distortion. In this manner, solutions for calculating deflections and stresses in Belleville springs have been obtained by Almen and Laszlo[1] who give the following formulas[2]:

$$P = \frac{E\,\delta\,C_2}{(1-\mu^2)r_o^2}\left[(h-\delta)\left(h-\frac{\delta}{2}\right)t+t^3\right] \quad (1)$$

where

$$C_2 = \left(\frac{\alpha+1}{\alpha-1} - \frac{2}{\log_e \alpha}\right)\pi\left(\frac{\alpha}{\alpha-1}\right)^2 \quad (2)$$

$$S_1 = -\frac{E\,\delta\,C_2}{(1-\mu^2)r_o^2}\left[C_1'\left(h-\frac{\delta}{2}\right)+C_2'\,t\right] \quad (3)$$

$$S_2 = -\frac{E\,\delta\,C_2}{(1-\mu^2)r_o^2}\left[C_1'\left(h-\frac{\delta}{2}\right)-C_2'\,t\right] \quad (4)$$

where

$$C_1' = \left(\frac{\alpha-1}{\log_e \alpha}-1\right)\frac{6}{\pi\log_e \alpha} \quad (5)$$

$$C_2' = \frac{3(\alpha-1)}{\pi\log_e \alpha} \quad (6)$$

A negative value for S_1 or S_2 denotes compression, a positive value tension.

The symbols have the following meanings:

P = axial load on spring, assumed uniformly distributed along inner edge, *Fig.* 1
δ = deflection due to load P
h = cone height with spring in unloaded condition, *Fig.* 2
E = modulus of elasticity of material
r_o = outside radius of spring, *Fig.* 2
r_i = inside radius of spring
t = disk thickness
$\alpha = r_o/r_i$
μ = Poisson's ratio (taken as .3 for steel)
S_1 = stress at upper inner edge of spring
S_2 = stress at lower inner edge of spring

Equation (1) may be written

$$P = C_1 C_2 \frac{E\,t^4}{r_o^2} \quad (7)$$

where

$$C_1 = \frac{\delta}{(1-\mu^2)\,t}\left[\left(\frac{h}{t}-\frac{\delta}{t}\right)\left(\frac{h}{t}-\frac{\delta}{2t}\right)+1\right] \quad (8)$$

To facilitate practical computations, in *Figs.* 5 and 6 the value C_1 has been plotted as a function of δ/t for various values of h/t, to cover the chief practical range of interest. To obtain greater accuracy, *Fig.* 6 may be used for the smaller values of C_1. Values of C_2 are plotted as functions of $\alpha = r_o/r_i$ in *Fig.* 7.

It should be noted that the factor C_1 is directly proportional to the load. Each curve of *Figs.* 5 and 6 therefore represents the load deflection diagram for the given value of h/t. Since these curves are independent of the ratio r_o/r_i between outer radius and

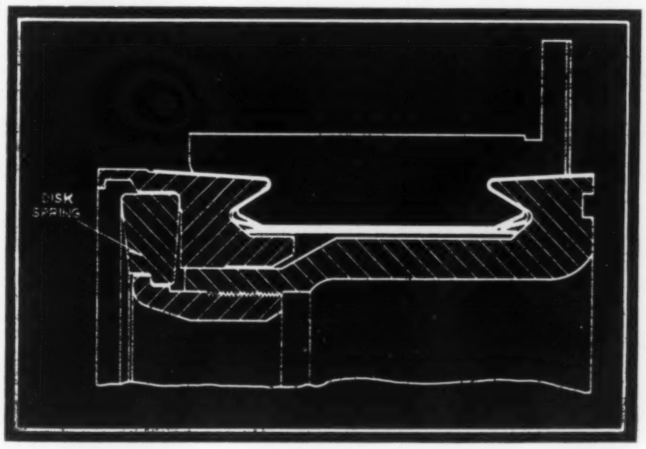


Fig. 4—Application of disk spring in motor commutator showing compactness of design

inner radius, it follows that the shape of the load-deflection characteristic can be changed materially only by altering the ratio h/t between initial cone height and disk thickness. At $h/t = \sqrt{2}$ (shown dotted in *Fig.* 6) the curve has a horizontal tangent and for a considerable range the rate is low. For $h/t = 1.5$ there is an even greater range of low spring rate but in this case the load drops slightly after reaching a maximum. When h/t reaches a value of about 2.8 the load drops below zero at the larger deflections, so that buckling of the spring occurs. As may be seen from *Fig.* 5, a wide variety of types of curves may be obtained by changing h/t. Interpolation may be used with sufficient accuracy for most practical purposes.

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[1] *"The Uniform Section Disc Spring", Trans. A.S.M.E., May,* 1936, *p.* 305.

[2] *The notation has been changed somewhat from that used by these writers.*

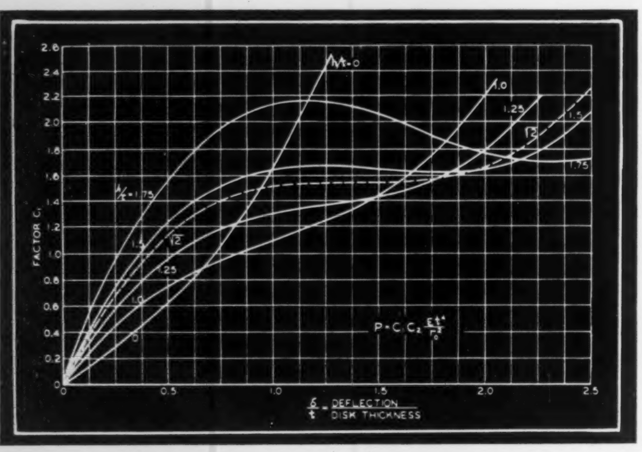

Fig. 6—Curves for determining deflection factor C_1 for the lower ratios of deflection to disk thickness

For calculating stress, Equation (3) or (4) may be written

$$S = K_1 \frac{E\,t^2}{r_0^2} \dots\dots\dots\dots (9)$$

where

$$K_1 = -\frac{C_2\,\delta}{(1-\mu^2)\,t}\left[C_1'\left(\frac{h}{t} - \frac{\delta}{2\,t}\right) \pm C_2'\right] \dots\dots (10)$$

If the positive sign is used before the constant C_2' the stress in the upper inner edge is obtained, while using the negative sign yields the stress at the lower inner edge. It is thus seen that the stress is a function of $\alpha = r_o/r_i$, δ/t, and h/t.

For facilitating practical computations, values of K_1 have been plotted as functions of the ratio δ/t for various values of h/t in *Figs.* 8 and 9. For ratios r_o/r_i equal to 1.5, the curves of *Fig.* 8 apply, a positive value of K_1 representing tension stress, a negative representing compression stress. It was found that within the range shown by the curves for values of h/t between 1 and 3 (where $\delta < 2\,h$) the maximum stress will be compression at the upper inner edge. For deflections δ equal to 2 h, the tension in the inner edge equals the compression in the upper, and for $\delta > 2\,h$, the tension in the lower edge becomes the limiting factor.

This is shown by the upper curve for $h/t = 1$, i.e. when $\delta/t = 2$ or $h = 2\,t$ then the compression and tension stresses at the two edges become equal, and for $\delta/t > 2$ the upper curve yields higher values. For most practical cases where h/t is between 1 and 3 the maximum stresses will be obtained by using the lower group of curves in *Figs.* 8 and 9. Interpolation may be used for intermediate values of h/t. In doubtful cases where $\delta > 2\,h$, the stress should be checked by using Equations 3 and 4.

In *Fig.* 9, a similar series of curves is given for computing the factor K_1 for a ratio $r_o/r_i = 2$. These curves also will hold within a few per cent for ratios r_o/r_i between 2 and 2.5. For ratios between 1.5 and 2 linear interpolation may be used between *Figs.* 8 and 9 with sufficient accuracy. Thus at a ratio $\alpha = r_o/r_i = 1.75$ the average value obtained from *Figs.* 8 and 9 should be used.

Application of Formulas

A considerable number of deflection tests has been carried out by Almen and Laszlo on Belleville springs of various proportions. These tests indicate that Equation 1 for calculating deflection, on which the curves of *Figs.* 5 and 6 are based, is sufficiently accurate for most practical purposes. However, this equation is not exact and in practice, therefore, deviations as high as 10 to 15 per cent from test values may be expected in some cases. For highest accuracy actual deflection tests should be carried out. If sufficient load cannot be obtained from one disk a stack of disks in parallel may be used as indicated on the sketch of *Fig.* 10. This figure also shows the load-deflection characteristic of such a stack of disks. The initial large deflection was due to flattening out of irregularities in the stack of springs. Although the disks were slight-

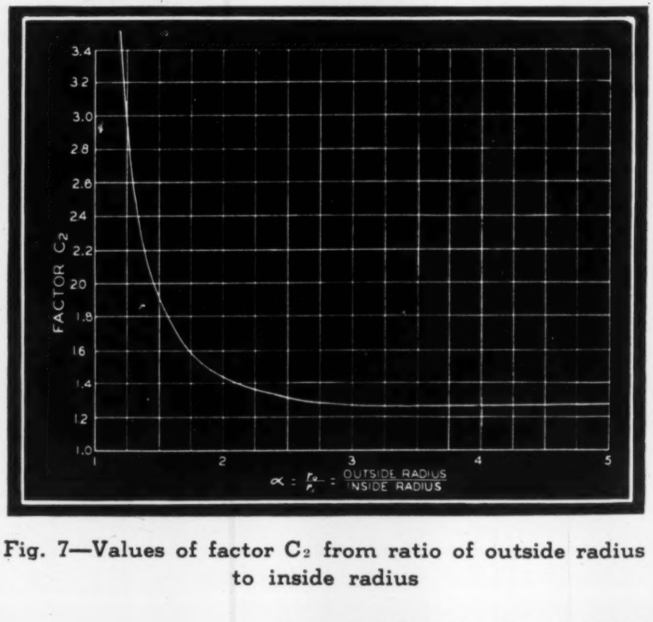

Fig. 7—Values of factor C_2 from ratio of outside radius to inside radius

ly oily, considerable friction between them was present as indicated by the hysteresis loop. By using a group of springs in this manner, the load is increased approximately in proportion to the number of disks.

Applying Belleville Springs

If the application is such that the springs are under a static load, permissible stresses of 200 to 220,000 pounds per square inch as calculated by Equations (3) and (4) are suggested by Almen and Laszlo for carbon spring steel. Although this stress seems extremely high, these writers state that experience shows the springs will function satisfactorily under static loads even at these stresses. The explanation may be that: (1) Yielding takes place so that the actual stress is less than the computed values; (2) for the usual application the maximum stress is compressive; and (3) the stress formula may be somewhat in error.

For applications under repeated loading so that fatigue enters, little data are at hand for determining maximum allowable stresses. It is probable, however, that under such conditions the permissible maximum stress would be reduced considerably, the amount of reduction depending on the stress range.

Example 1. To illustrate the use of the curves in *Figs*. 5 to 9, assume that a spring is to be designed for the following conditions: The spring is for use in a gasket application where the load is to be held approximately constant at 6000 pounds so that the type of load-deflection curve desired is that for $h/t = 1.5$ (*Fig*. 1). The space available will permit using an 8½ inch outside diameter spring. Deflection of the spring may vary between ⅛ and ¼ inch at the design load and the maximum stress is to be limited to 200,000 pounds per square inch. Taking $r_o = 4\frac{1}{4}$ inches, $r_i = 2\frac{1}{8}$ inch, $\alpha = r_o/r_i = 2$, from Equation (9) we have $S = K_1 E t^2/r_o^2$ where $K_1 = -6.7$ from *Fig*. 9 for $h/t = 1.5$, this being the maximum value. Solving this for t, and taking $S = -200{,}000$ pounds per square inch (compression), we find

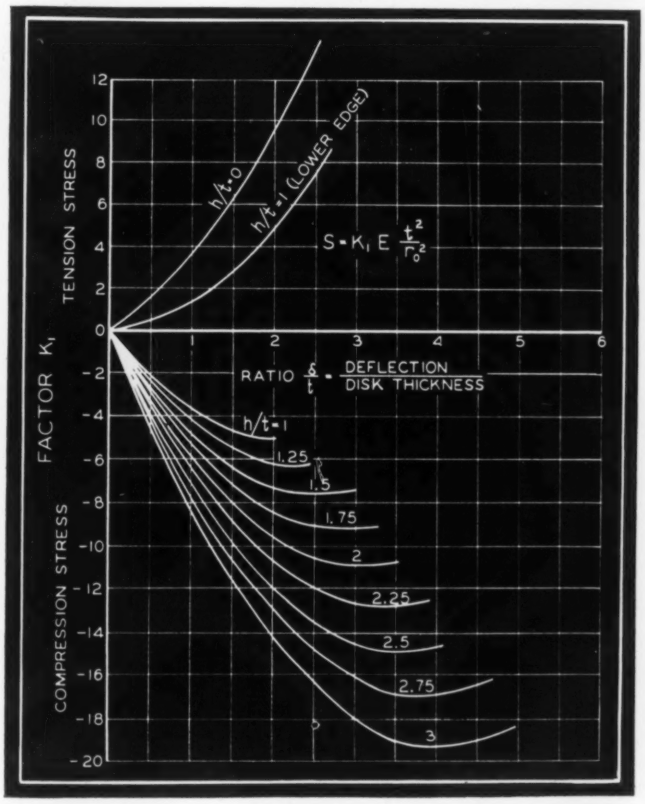

Fig. 8—Stress factor K₁ for values of outside radius to inside radius = 1.5

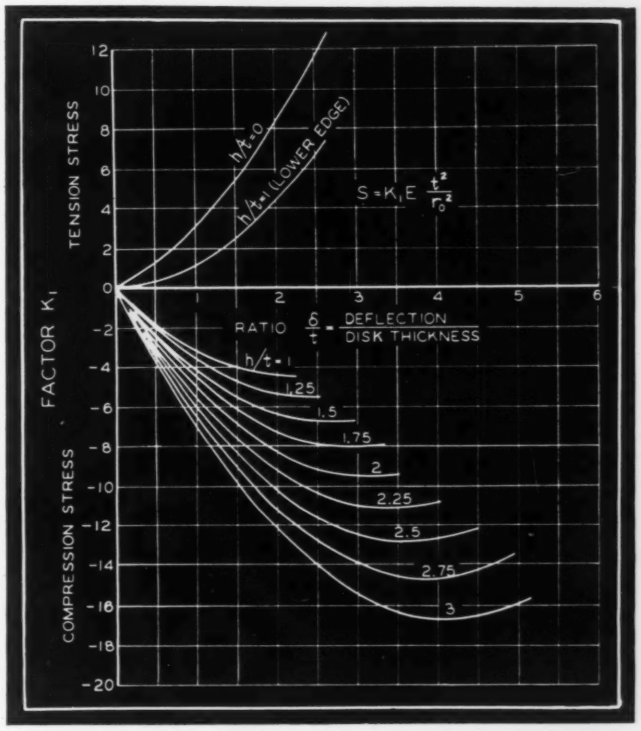

Fig. 9—Stress factor K₁ for values of outside radius to inside radius = 2 to 2.5

$$t = r_o \sqrt{\frac{S}{K_1 E}} = 4.25 \sqrt{\frac{200{,}000}{6.7 \times 30 \times 10^6}} = .134 \textit{ inch}$$

From *Fig*. 6 for $h/t = 1.5$, $C_1 = 1.68$ on the flat part of the curve and from *Fig*. 7, for $\alpha = 2$, $C_2 = 1.45$. From Equation (7) the load per disk will be

$$P = C_1 C_2 \frac{E t^4}{r_o^2} = \frac{1.68 \times 1.45 \times 30 \times 10^6 \times (.134)^4}{(4.25)^2}$$

$$= 1300 \textit{ pounds}$$

Since we desire 6000 pounds it will be necessary to use 5 springs in parallel, which will give approximately the right load. From *Fig*. 6 it is seen that for $h/t = 1.5$, C_1 is approximately constant from $\delta/t = .75$ to $\delta/t = 2.1$. Since $t = .134$, this means the load will be constant from $\delta = .75 \text{ X } .134 = .1$ inch to $\delta = .28$ inch which is about what is required. If the maximum deflection is ¼ inch the maximum value of δ/t will be .25/.134 or about 2. From *Fig*. 9, for $\delta/t = 2$

the factor K_1 will be about —6.4 instead of —6.7 which means that the calculated maximum stress will be slightly less than 200,000 pounds per square inch. The calculated load may be reduced from 6500 pounds to 6000 pounds by reducing the thickness about 2 per cent.

Where Snap Action Is Desired

Example 2. Assume that a curve such as that shown in *Fig.* 5 for $h/t = 2.5$ is desired for a snap action device, to operate in such a way that when the load reaches a certain point represented by the peak on the curve, the system becomes unstable and a large deflection occurs with resulting snap-action. Assume that a maximum load of about 520 pounds is desired, that space is available for an 8 inch diameter disk and that a stop is provided so that the spring may deflect ¼ inch before coming against the stop. It is desired that at ¼ inch deflection when the spring is against the stop the load will be represented by point on curve for $h/t = 2.5$ corresponding to $\delta/t = 3$. Since at maximum deflection $\delta = ¼$ inch this means that $t = .25/3 = .0833$ inch and $h = 2.5 \times .0833 = .208$ inch. Assuming $\alpha = 2$, from *Fig.* 9 we find $K_1 = -12.5$ for $\delta/t = 3$, $h/t = 2.5$. From Equation (9), solving for r_o

$$r_o = \sqrt{\frac{K_1 E t^2}{S}}$$

Taking S = —180,000 pounds per square inch (compression), $t = .0833$ inch and solving, $r_o = 3.8$ inch, say 3¾ inch. From *Fig.* 7, for $\alpha = 2$, $C_2 = 1.45$ and from *Fig.* 5, the maximum value of C_1 (corresponding to maximum load) for $h/t = 2.5$ is 4.6. From Equation (7) the peak load is

$$P_{max.} = C_1 C_2 \frac{E t^4}{r_o^2} = \frac{4.6 \times 1.45 \times 30 \times 10^6 \times (.083)^4}{(3.75)^2}$$
$$= 675 \textit{ pounds}$$

This load is too high since 520 pounds was desired. To get a lower peak load, since the latter from Equation (7) increases as t^4 (other things being equal) the thickness may be reduced in the ratio

$$\sqrt[4]{\frac{520}{676}} = .935$$

Thus $t = .0833 \times .935 = .078$ inch. For the same shape of curve we must keep h/t the same (2.5) so that $h = 2.5 \times .078 = .195$ inch. At ¼ inch deflection, δ/t will be $.25/.078 = 3.2$ which will bring us somewhat beyond the point on the curve for $\delta/t = 3$, but in this case this is permissible. Also the maximum stress will not be changed since from *Fig.* 8, for $h/t = 2.5$, $\delta/t = 3.2$, the factor K_1 is practically the same as for $\delta/t = 3$. From *Fig.* 5, for $\delta/t = 3.2$, $h/t = 2.5$ we obtain $C_1 = 1.3$. Since $C_1 = 4.6$ at the peak load, the load when the spring is against the stop will be $1.3/4.6 \times 520 = 147$ pounds.

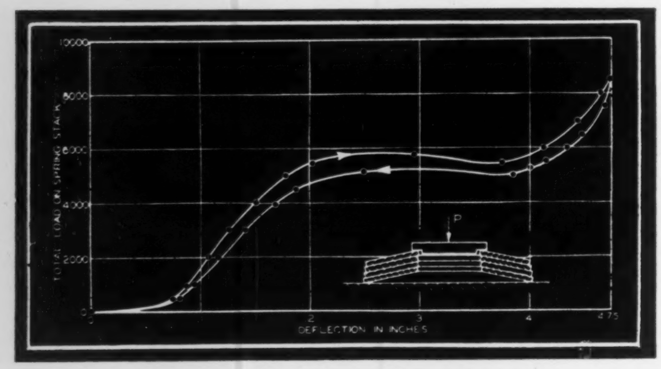

Fig. 10—Deflection test of stack of four steel Belleville springs (in inches, outside radius = 4½, inside radius = 1¾, height = .212, thickness = .148)

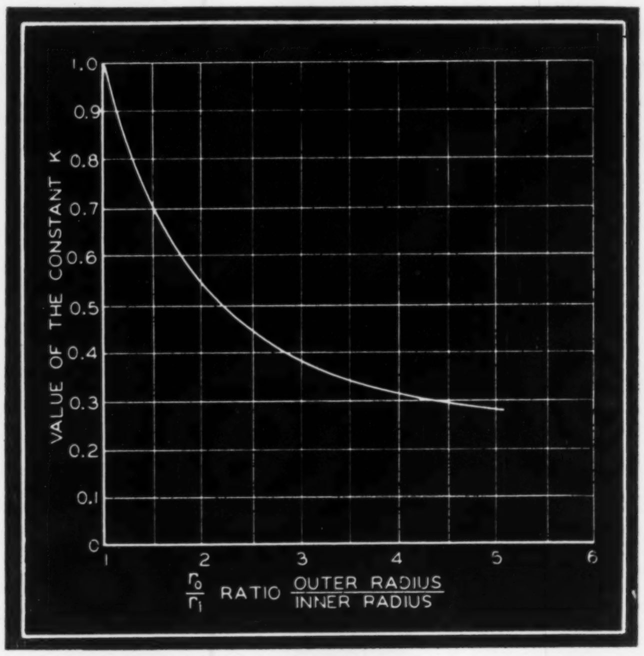

Fig. 11—Stress constant K for radially tapered disk springs

Radially Tapered Disk Springs

If the disk spring is made flat and has a thickness which is proportional to the radius, *Fig.* 3, as a first approximation the stress will be constant along a radius. This may be explained as follows. If a radial cross section rotates through an angle ϕ (assuming no distortion of the section) then the radial displacement of a point on the surface at a radius r will be $t\phi/2$ and the unit elongation $t\phi/2r$, where t is the thickness. By making t/r constant[3] the unit elongation and hence the stress will be constant.

The calculation of initially flat radially tapered disk springs may be carried out by using the same assumption as that discussed previously for calculating Belleville springs, i.e., during deflection radial cross sec-

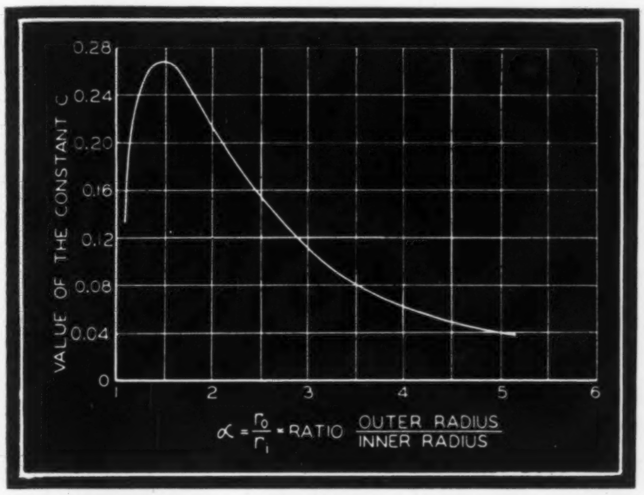

Fig. 12—Deflection constant C for radially tapered disk springs

tions rotate without distortion. This will yield an approximate solution. However, for this case a more exact solution, based on flat plate theory is available[4]. This indicates that the approximate solution is correct to within a few per cent for deflections in cases where the ratio of outside to inside diameter is less than 2.5. For stress, however, the error is considerably greater, amounting to about 25 per cent at a ratio $r_o/r_i = 2$.

Using the more exact theory, the stresses and deflections may be computed from[5]

$$S = K \frac{P}{t_i^2} \quad \ldots\ldots (11)$$

$$\delta = C \frac{P r_o^2}{E t_i^3} \quad \ldots\ldots (12)$$

where

S = maximum stress in the spring (this occurs at the lower inner edge)
δ = maximum deflection at load P
t_i = thickness of disk at inside edge
E = modulus of elasticity of the material
$\left.\begin{array}{l} C \\ K \end{array}\right\}$ = factors depending on the ratio r_o/r_i between outer radius and inner radius and may be read from the curves of *Figs.* 12 and 11 respectively

Numerical values of the constants C and K for various values of $\alpha = r_o/r_i$ are given in Table I.

TABLE I

Stress Constant K and Deflection Constant C for Radially Tapered Disk Springs

α^* =	1	1.25	1.5	2	3	4	5
K =	.985	.819	.696	.536	.382	.315	.28
C =	0	.243	.271	.213	.11	.062	.039

$^*\alpha = r_o/r_1$

In the practical application of radially tapered disk springs, the load usually is applied at some little distance inside the edges of the spring as indicated in *Fig.* 13. In such cases, it is advisable to figure the spring as though the load were applied exactly at the edge. The resulting stress is then multiplied by the ratio $d/(r_o - r_i)$, while the deflection is multiplied by the ratio $d^2/(r_o - r_i)^2$ to take the inward displacement of the point of load application into account. This method will yield a better approximation to the maximum stress and the deflection at the point of load application.

If the deflection is larger than about half the thickness t_i, the load should be calculated from:

$$P = \frac{E t_i^3 \delta}{C r_o^2} \left[1 + \frac{1.5 \delta^2}{t_i^2(\alpha^2 + \alpha + 1)} \right] \quad \ldots\ldots (13)$$

Since the second term within the brackets usually is small compared to unity, the deflection δ may first be computed by using Equation (12), assuming the load is given. This calculated value for δ is then divided by the term in brackets, which is

$$\left[1 + \frac{1.5 \delta^2}{t_i^2(\alpha^2 + \alpha + 1)} \right]$$

This will result in a second approximation for the deflection δ which will usually be sufficiently accurate. A check may be made by substituting in Equation (13).

The stress and deflection equations for initially flat radially tapered disk springs given here have been checked by numerous deflection tests and strain measurements on actual springs using Huggenberger extensometers[4]. Good agreement was found between test and calculated results.

Investigation shows that for a given load, thickness t_o, and stress that the maximum flexibility for radially tapered springs is obtained by using a ratio $\alpha = r_o/r_i$ of about 2. It is usually of advantage therefore to hold this ratio at this value, unless other design limitations dictate a different one.

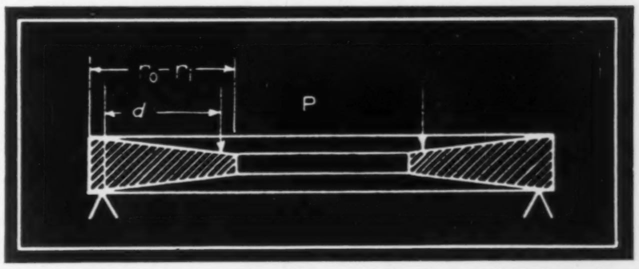

Fig. 13—Application of load in radially tapered disk springs

Assume that it is desired to determine maximum stress and deflection for a radially tapered disk spring for a motor commutator, (*Fig.* 4). The dimensions are as follows: $r_o = 9$ inches, $r_i = 6$ inches, $\alpha = 1.5$, $t_i = ¾$ inch. Maximum load P is 90,000 pounds.

From *Figs.* 11 and 12 we find for $\alpha = 1.5$ that $C =$

(*Concluded on Page* 62)

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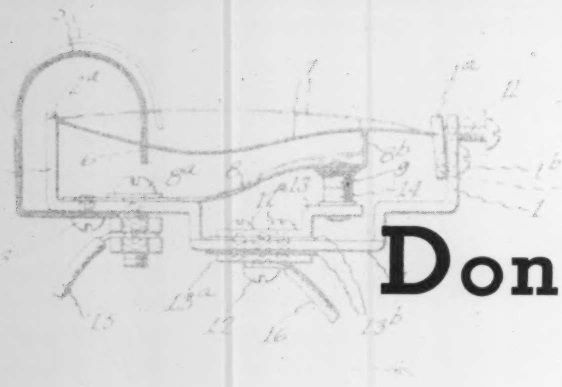
[3] *This expedient was suggested by W. A. Brecht of Westinghouse company.*

[4] *The "Radially Tapered Disc Spring", by W. A. Brecht and the writer; Transactions, A.S.M.E.,* 1930.

[5] *It is assumed, in using these equations, that the deflections are not more than about half the thickness* t_i*. This will include most practical cases where initially flat springs are used.*



Don't Skimp on Your Pa

By George V. Woodling

INGENUITY in designing and improving machines may well be supplemented by a knowledge gained in analyzing prior patents. Thorough working knowledge of old devices not only inspires the creation of new ones, but also enables the designer to begin his development work where the prior art left off. In this way there is no overlapping or duplication between a new development and prior inventions.

Experience reveals that much expense and wasted effort may be avoided if the designer informs the patent department or a patent attorney regarding developments instead of waiting until the final design is completed. The designer is benefited because the patent department through the making of patent searches can co-operate to guide new developments along lines which will avoid patent infringement. The patent department is helped because an intimate knowledge is gained of the new designs through their various steps. This co-operation enlarges the appreciation of the scope of the inventions and represents a considerable force in bringing about a broadening of the patent protection which might be obtained.

Facilitates Purchase of Patents

Patent searches also are helpful in several other aspects. For instance, the knowledge gained through patent searches enables a manufacturing company to purchase adversely-held patents at reasonable figures, because after commercial activity is once started by the exploiting company, the bargaining value of such patents is greatly enhanced. In addition, a patent search enables the company to judge the merit of patents it is buying and cautions it against worthless ones. By purchasing worthwhile patents, the company is afforded immediate protection which tends to discourage infringing competition.

The United States Patent Office maintains a public search room, shown in *Fig.* 2, to facilitate the making of patent searches. There more than two million United States patents are classified according to the various arts, including more than 300 general classes, and 3000 subclasses. Thus, the field of search may be limited to one or more subclasses. As an aid in locating pertinent patents, a "Manual of Classification" prepared by the patent office is used as an index or guide to give the general classes or subclasses. A facsimile of a page from the manual is shown in *Fig.* 3. This particular page relates to general "Class 200, Electricity—Circuit Makers and Breakers," which class contains 172 subclasses some of which are shown on this page. The subclasses vary in size and each may contain as many as several hundred patents. When they become too large, they are reclassified into additional subclasses.

Initial Search Should Be Limited

In making a search, the field of search should be determined first with the object of limiting it to a few of the most fertile subclasses. For instance, in directing a search for the double snap switch shown in *Fig.* 1, the searcher would be likely to examine subclass 67, "Double Snap," listed under the general subject "Snap," see the page from the manual. If this subclass should fail to reveal any pertinent patents, the searcher then would direct his attention to one or more of the other related classes.

Searchers may take the classified patents from the file, leaf through them, and select those which appear to be the closest to the invention in question. Thus, a search upon the snap-over switch shown in *Fig.* 1 would reveal a group of patents, some of which are indicated on the first page of this article. All of these devices comprise in some form or other the provision of a double snap-over switch to accomplish a quick break of the circuit.

United States Patent Office searches comprise six distinct types:

(1) Preliminary
(2) State of Art
(3) Assignment
(4) Index
(5) Infringement
(6) Validity.

PRELIMINARY SEARCH: This type of search is

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P t Searches!

made prior to the filing of the patent application to forecast the likelihood of obtaining a patent and thus avoid the waste of money incident to the filing of applications upon inventions which cannot be patented. If the search indicates that the invention is old and unpatentable, the company saves the difference between the cost of the search and what the increased cost would have been if an application had been filed without a search.

Because of the general nature of preliminary searches, they cannot be strictly relied upon. A search may reveal that an idea is new, but when the inventor files his patent application he may then learn that the patent office has rejected the claims as unpatentable because of prior patents which the searcher did not find. Furthermore, pending applications are held in strict secrecy, and therefore patent searches do not disclose whether another inventor has a pending application upon the same subject. Thus a patent that is pertinent to an invention being searched may be granted a week after the search is made and thereby change the entire results of the search. For this reason it is not safe to rely too strongly upon preliminary searches.

In forecasting the possibility of obtaining a patent before making application, the proposed device under investigation is compared with the devices shown and described in the patents located in the preliminary search, and then the substantial identity between prior patents and the proposed device is observed. If the substantial identity between the prior patents and the proposed device is close, then the possibility of obtaining a patent presents a legal struggle. If on the other hand there is a wide departure between the identity of the prior patents and the device under consideration, the possibility of obtaining a patent assumes a brighter outlook.

Opinions Differ Regarding Patentability

An important stage in connection with preliminary searches that should be stressed at this time is the problem of interpreting border-line cases. Two or more attorneys may examine the patents found in the preliminary search with reference to the device under investigation but, because of the weight given to different factors, each may present a different opinion as to the degree of patentability. A mistake in judgment, advising a company not to file a patent application, may result in considerable loss.

Often a question is asked regarding the propriety of filing a patent application without making a search, in the hope that there is nothing like the new device in the patent office and that a search in such a case would be unnecessary. First of all it should be understood that the mere fact that a proposed invention cannot be found on the market is no proof whatsoever that it cannot be found in the patent office. It is difficult to set forth an all-inclusive answer to the question, but the following considerations (as discussed in the author's book *"Inventions and Their Protection"*) may be used as a general guide.

It usually is desirable to make a patent search before filing an application if the problem which the proposed invention solves is

(1) Old and generally well known, and the so-

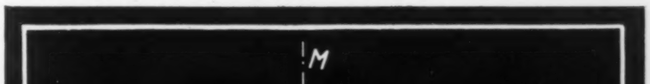


Fig. 1—Typical part, a double-snap switch, for which search is being undertaken

lution is such that others are likely to solve the problem in the same way
(2) Old and generally well known, and the solution to the problem comprises but a "single" thought.

It ordinarily is unnecessary to make a patent search before filing application if the problem which the proposed invention solves is

(1) Old and generally well known, and the solution is the reverse of that which other persons would be likely to attempt in order to solve the problem
(2) Old and generally well known, and the solution to the problem involves complex thought and the co-ordination of several ideas
(3) Old and generally well known, has baffled those skilled in the art, and the solution to the problem is discovered by pure accident
(4) Old and generally well known, has baffled those skilled in the art, and the solution involves a long series of tests to obtain the exact ratios among the various parts of the invention
(5) New and there has not as yet been sufficient time for the patent office to grant any patents. A search would not reveal subject matter contained in pending applications, because they are maintained in strict secrecy
(6) Solved by one who has played a prominent part in the development of the specific field and is well acquainted with all of the recent developments.

STATE OF ART search is broader in scope than a preliminary search and ordinarily is required to assist the engineering department in planning a new line. It usually is made when the department has not as yet developed any definite ideas regarding the design of the new machines. The purpose of such a search is to give a general idea of the patent situation regarding proposed new designs before going ahead with actual details. This prevents an overlapping or duplication of the new developments over prior devices. While making a state of art search, the searcher reviews several relating subclasses to give the engineering department a wide and general knowledge of the field.

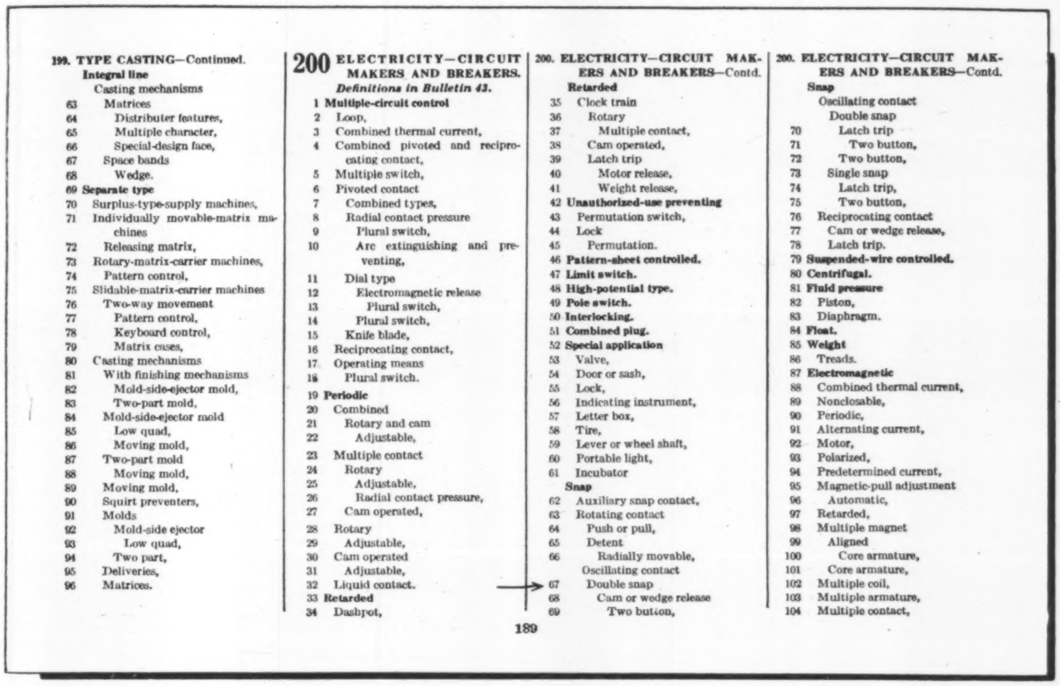
ASSIGNMENT SEARCH: This is made to ascertain the present recorded owner of a particular patent. Such a search is advisable when a company desires to acquire rights under certain patents to give greater assurance that it is dealing with the proper owner. These searches give the recorded change in the title of the patent from the inventor to the present recorded owner.

Index File Names Patentee

INDEX SEARCH: Made to determine what patents have been issued to a particular inventor or company. The index file at the patent office contains an alphabetical list of patentees and corresponding patent data from which the searcher may obtain sufficient information to order copies of the patents. Thus, for example, the number of patents that have been issued to the XZY Co. can be found by making an index search against the particular company.

INFRINGEMENT SEARCH: Determines if a proposed device or improvement for manufacture and sale will infringe a claim or claims of an unexpired patent. The fact that the manufacturer may have obtained a patent upon the proposed device does not free him of infringement. It still may be necessary for the manufacturer to conduct an infringement search to make sure that no patent difficulties will arise after

Fig. 2—Investigation of hundreds of patents is carried out daily at this search room of the patent office



199. TYPE CASTING—Continued.
Integral line
Casting mechanisms
63 Matrices
64 Distributer features,
65 Multiple character,
66 Special-design face,
67 Space bands
68 Wedge.
69 **Separate type**
70 Surplus-type-supply machines,
71 Individually movable-matrix machines
72 Releasing matrix,
73 Rotary-matrix-carrier machines,
74 Pattern control,
75 Slidable-matrix-carrier machines
76 Two-way movement
77 Pattern control,
78 Keyboard control,
79 Matrix cases,
80 Casting mechanisms
81 With finishing mechanisms
82 Mold-side-ejector mold,
83 Two-part mold,
84 Mold-side-ejector mold
85 Low quad,
86 Moving mold,
87 Two-part mold
88 Moving mold,
89 Moving mold,
90 Squirt preventers,
91 Molds
92 Mold-side ejector
93 Low quad,
94 Two part,
95 Deliveries,
96 Matrices.

200 ELECTRICITY—CIRCUIT MAKERS AND BREAKERS.
Definitions in Bulletin 43.
1 **Multiple-circuit control**
2 Loop,
3 Combined thermal current,
4 Combined pivoted and reciprocating contact,
5 Multiple switch,
6 Pivoted contact
7 Combined types,
8 Radial contact pressure
9 Plural switch,
10 Arc extinguishing and preventing,
11 Dial type
12 Electromagnetic release
13 Plural switch,
14 Plural switch,
15 Knife blade,
16 Reciprocating contact,
17 Operating means
18 Plural switch.
19 **Periodic**
20 Combined
21 Rotary and cam
22 Adjustable,
23 Multiple contact
24 Rotary
25 Adjustable,
26 Radial contact pressure,
27 Cam operated,
28 Rotary
29 Adjustable,
30 Cam operated
31 Adjustable,
32 Liquid contact.
33 **Retarded**
34 Dashpot,

189

200. ELECTRICITY—CIRCUIT MAKERS AND BREAKERS—Contd.
Retarded
35 Clock train
36 Rotary
37 Multiple contact,
38 Cam operated,
39 Latch trip
40 Motor release,
41 Weight release,
42 **Unauthorized-use preventing**
43 Permutation switch,
44 Lock
45 Permutation.
46 **Pattern-sheet controlled.**
47 **Limit switch.**
48 **High-potential type.**
49 **Pole switch.**
50 **Interlocking.**
51 **Combined plug.**
52 **Special application**
53 Valve,
54 Door or sash,
55 Lock,
56 Indicating instrument,
57 Letter box,
58 Tire,
59 Lever or wheel shaft,
60 Portable light,
61 Incubator
Snap
62 Auxiliary snap contact,
63 Rotating contact
64 Push or pull,
65 Detent
66 Radially movable,
Oscillating contact
67 Double snap
68 Cam or wedge release
69 Two button,

200. ELECTRICITY—CIRCUIT MAKERS AND BREAKERS—Contd.
Snap
Oscillating contact
Double snap
70 Latch trip
71 Two button,
72 Two button,
73 Single snap
74 Latch trip,
75 Two button,
76 Reciprocating contact
77 Cam or wedge release,
78 Latch trip.
79 **Suspended-wire controlled.**
80 **Centrifugal.**
81 **Fluid pressure**
82 Piston,
83 Diaphragm.
84 **Float.**
85 **Weight**
86 Treads.
87 **Electromagnetic**
88 Combined thermal current,
89 Nonclosable,
90 Periodic,
91 Alternating current,
92 Motor,
93 Polarized,
94 Predetermined current,
95 Magnetic-pull adjustment
96 Automatic,
97 Retarded,
98 Multiple magnet
99 Aligned
100 Core armature,
101 Core armature,
102 Multiple coil,
103 Multiple armature,
104 Multiple contact,

Fig. 3—Facsimile of page from the manual of classification of patents. Note "Double snap" under classification 67

the proposed device is introduced on the market. New patents can be granted to the company on improvements, and thus competitors can be prevented from manufacturing or selling machines with these improvements. However, the company may not be able legally to manufacture and sell the improved machines without a license agreement under earlier dominating patents which cover basic factors.

Validity Search is made to determine the validity or nonvalidity of the claims of a specific patent. Probably the most frequent use of a validity search is in a patent law suit wherein the defendant endeavors to prove to the court that, in view of the patents found in the validity search the claims in the plaintiff's patent are invalid, notwithstanding the fact that the patent office allowed the claims.

Some of the larger manufacturing corporations keep a complete file of all the patents pertaining to their products and a complete search may be made in the company's patent files without conducting a search at the patent office. The company's patent files usually are kept up to date by ordering copies of all patents which relate in any respect to the company's business.

Mile-Long Machine Performs Continuous Process

(*Concluded from Page* 29)

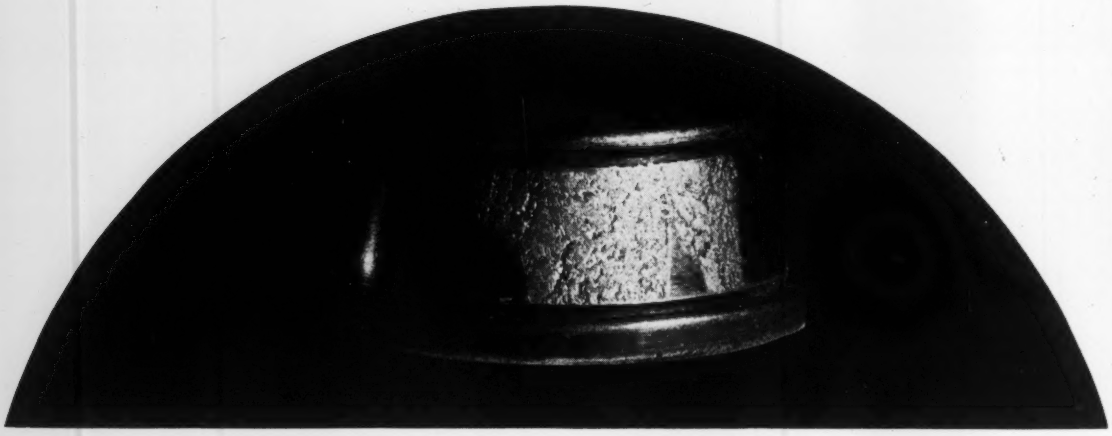
at the bottom of the machine are what is known as twister tables, grouped in series of five, supporting 100 rayon twisting spindles over an overall length of 44 feet. The tables are counterweighted and suspended by pulleys and shafts on each side of the machine frame and operated from the cam at the drive end.

All motors are flange mounted, and chain tensions are maintained by spring-backed automatic idlers. Force feed lubrication from an oil sump in the bottom of each casing is provided for all chain drives.

In connection with materials not previously discussed, it should be mentioned that beneath and back of each process reel is a molded hard rubber tray. Distribution and reclaiming of processing liquors to and from the reels would have been difficult without the development of such a chemically resistant tray. Molded hard rubber pipe and fittings also contribute to the economical circulation system for many of the liquors.

In the reels as well as in other small shaft mountings, use of self-lubricating bearings reduces lubrication and maintenance costs and insures reliability.

It may be said in conclusion that the overall problem involved in the design and construction of this continuous machine required balancing the first cost of the equipment and its probable cost of operation and servicing against the handling expense eliminated and the contemplated improvement in the quality of the product. As has been discussed, cost of construction was lowered considerably by welding easily fabricated steel sections. Servicing costs have been held down by providing overall access for repairs and a high degree of parts interchangeability. And through the very development of a continuous automatic machine the total elapsed time for extruding, coagulating, processing, drying and twisting is cut to about six minutes, against as much as four or five days using batch treatment.



How to Reduce Surface Fatigue

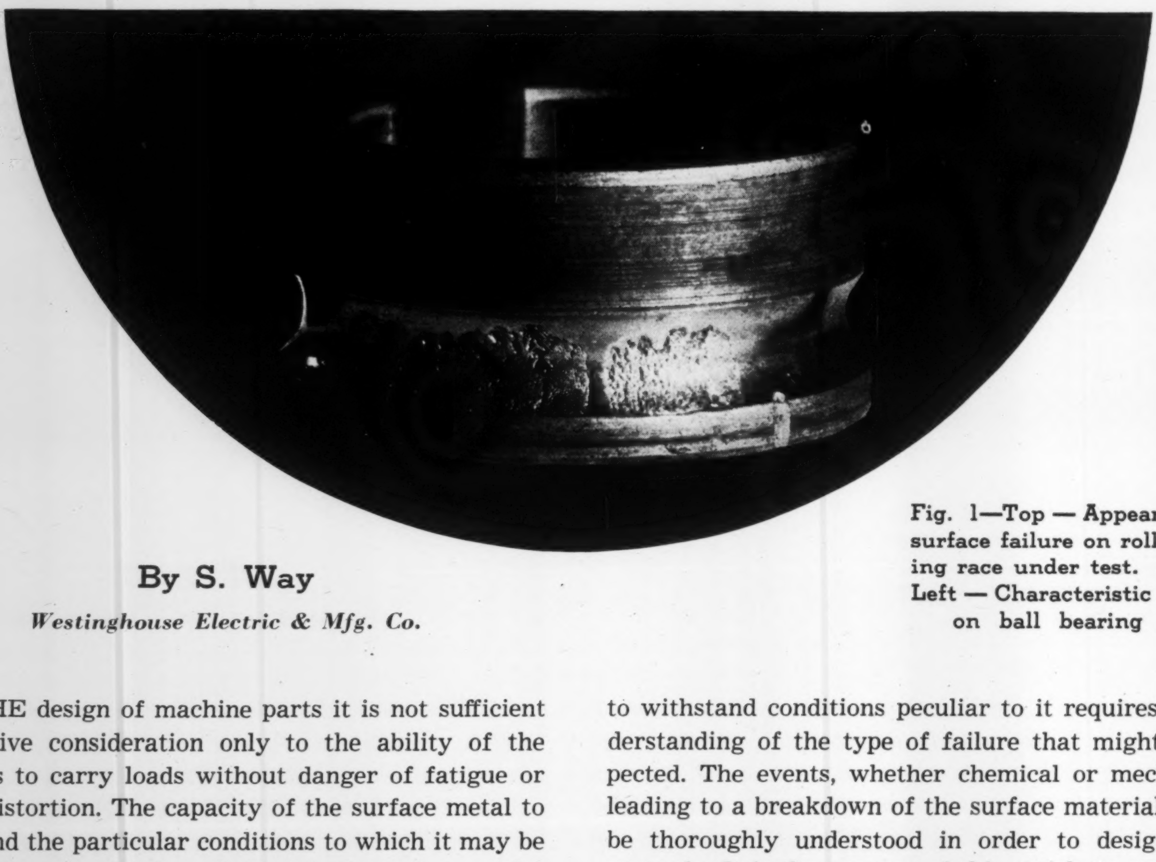


Fig. 1—Top — Appearance of surface failure on roller bearing race under test. Fig. 2—Left — Characteristic failure on ball bearing race

By S. Way

Westinghouse Electric & Mfg. Co.

IN THE design of machine parts it is not sufficient to give consideration only to the ability of the parts to carry loads without danger of fatigue or undue distortion. The capacity of the surface metal to withstand the particular conditions to which it may be subjected must also be considered. Typical examples involving these problems are antifriction bearings and gears.

A bearing race as a structural element may be amply strong to resist deformation or rupture as a whole, yet if it cannot withstand the contact stresses in the immediate vicinity of the loaded areas under the balls or rollers it is subject to failure. Similarly, gear teeth may be amply strong as far as carrying bending stresses are concerned but, if the surface metal is unable to carry the contact pressures between teeth, pitting results which may be destructive.

Design of a machine part to enable the surface metal to withstand conditions peculiar to it requires an understanding of the type of failure that might be expected. The events, whether chemical or mechanical, leading to a breakdown of the surface material should be thoroughly understood in order to design parts properly. It is the purpose of this article to emphasize the nature of, and the main factors influencing, one particular class of failure, namely, surface fatigue due to repeated contact stresses.

Surface fatigue is one of several types of surface failure which may occur when two metal surfaces are in rolling or sliding contact. These failures may be listed as follows:

(1) Scoring, or the removal of material from one body due to the scratching by the protuberances of the other

(2) Abrasion, or the removal of material

from one or both of the bodies because of the cutting action of particles between them

(3) Seizing, followed by tearing out of particles

(4) Flaking, or progressive corrosion accompanied by the breaking off of oxide and metal particles. This happens mainly on unlubricated surfaces

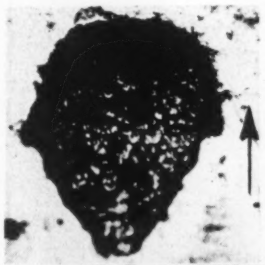
(5) Pitting, or surface fatigue.

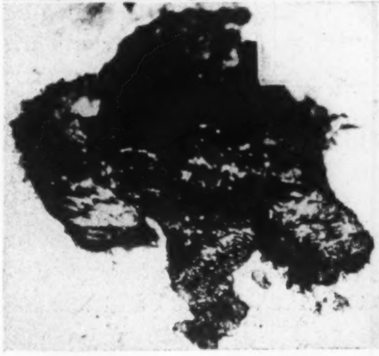
What is commonly called "wear" is usually a combination of several of these forms of failure and possibly some others. The particular type of surface failure that occurs on a machine part will depend on many factors such as the shape of the bodies, the surrounding medium or lubricant, the relative amounts of sliding and rolling, the speed, the load and the physical and chemical properties of the materials.

Examples of Surface Failures

When two metal surfaces are in rolling contact, with which may be combined a moderate amount of sliding, and when the surfaces are lubricated with a liquid, the type of failure that is apt to occur is surface fatigue. Thus, the surface failure of gear teeth, if not due to seizing or scoring, and the failure that takes place on balls, rollers and races of antifriction bearings are surface fatigue failures. Like other fatigue failures, surface fatigue is characterized by the formation of a fatigue crack due to repeated applications of the load on the region of contact. Several million load applications may be necessary to start the crack. The final appearance of the failure depends to a large extent on the shape of the bodies and their physical properties.

The first example, *Fig.* 3, shows a surface fatigue failure, or pit, on a steel gear tooth of medium hardness. This pit occurred at a location where there was sliding between the mating teeth; however, similar pits are observed at the pitch line where there is no sliding. The second example, *Fig.* 5, shows a pit produced on one of a pair of cylindrical rollers running together in pure rolling contact. The rollers were of a material similar to the gear tooth of *Fig.* 3. Two characteristic features of the pits shown in *Figs.* 3 and 5 should be noted: The general form of the pit is fan-shaped, and the pits are always oriented the same way with respect to the direction of motion of the load, shown by the arrow.





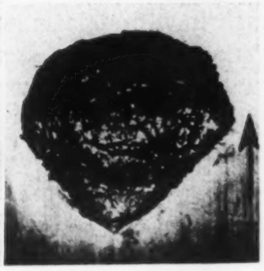


Fig. 3—Left—Pit on gear tooth. Fig. 4—Left, below—Failure on roller of spherical roller bearing. Fig. 5—Below—Pit on roller bearing. Arrows show direction of rotation. Magnification, 14X

The third example of surface fatigue, *Fig.* 4, shows a pit on a roller from a spherical roller bearing. Here, the characteristic fan shape is missing. In general, pits on very hard materials are of quite irregular shape.

Examples in *Figs.* 1 and 2, show pitting of a roller bearing race and a ball bearing race respectively, after destruction tests. In such cases the pitted areas are apt to be quite large, because the pitted regions appear to grow continually as a result of the shearing off of material at the edge of the pit. This shearing action is illustrated in *Fig.* 6, where cracks parallel to the edge of the pitted region can be seen. This progressive growth does not take place in the case of the gear tooth type of pitting shown in *Figs.* 3 and 5. The latter pitting results from the separation from the main body of material of a single particle, following the growth of a crack.

Another example of pitting of yet a different form is shown in *Fig.* 7. Failures like this occur on the balls of self-aligning or deep groove ball bearings. The pit

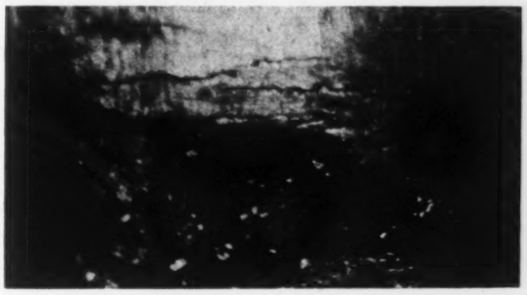


Fig. 6—Progression of crack on ball bearing race. Magnification 34X

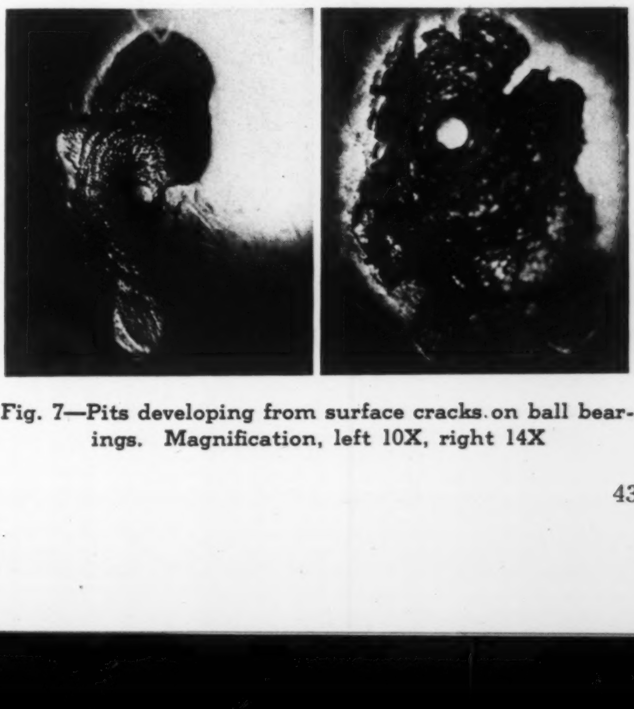


Fig. 7—Pits developing from surface cracks on ball bearings. Magnification, left 10X, right 14X

has an elevated summit in the middle, the surface of which is the original surface of the ball.

These examples illustrate the point that the final appearance of a surface fatigue failure depends on the nature of the contacting bodies. To gain an understanding of how these failures take place it is necessary to study them at an early stage. When this is done it is found that in beginning they have certain common features.

Cracks Start at Surface

Before the pit is formed there can be seen at the surface a small fatigue crack. Some of these cracks and the pits that resulted from them on test rollers are shown in *Fig.* 8. A surface fatigue crack on a ball bearing race is shown in *Fig.* 9. The cracks on gear teeth and test rollers have been observed to start always on that side of the future pit which first meets the oncoming load.

Pitting fatigue cracks can also be studied at an early stage by making sectional cuts through them as soon as they are observed at the surface. When the sectioning plane is perpendicular to the axis of rotation, the shape of the crack below the surface can be seen, and the cracks are found to slope obliquely into the metal, as shown in *Figs.* 10 and 11. It is of interest that the surface fatigue cracks on gear teeth, test rollers, and ball and roller bearing races all slope obliquely into the metal at an acute angle to the surface. Furthermore, the direction of slope of these cracks for the case of gears and rollers has always been found to bear the same relation to the direction of the approaching load. There is evidence that the ball and roller bearing pitting cracks also have a uniform orientation.

Examination of the pits on the balls shown in *Fig.* 7 indicates that the cracks probably started at the central summit and worked out radially. The formation of such a crack can be explained by a study of the Hertz system of contact stresses between ball and race. This theory* shows that at the edge of the contact area, in case it is circular, there will be a radial tensile stress of magnitude $0.133P_{max}$ and a circumferential compressive stress—$0.133P_{max}$ where P_{max} is the maximum compressive stress in the contact area. There is thus a shearing stress at the edge of the contact area of magnitude $0.133P_{max}$. Greater shearing stresses occur below the surface, but only in regions where there is also high hydrostatic compression, and it is therefore questionable if these shearing stresses are dangerous as far as fatigue is concerned. At the edge of the contact area on the surface there is no hydrostatic compression.

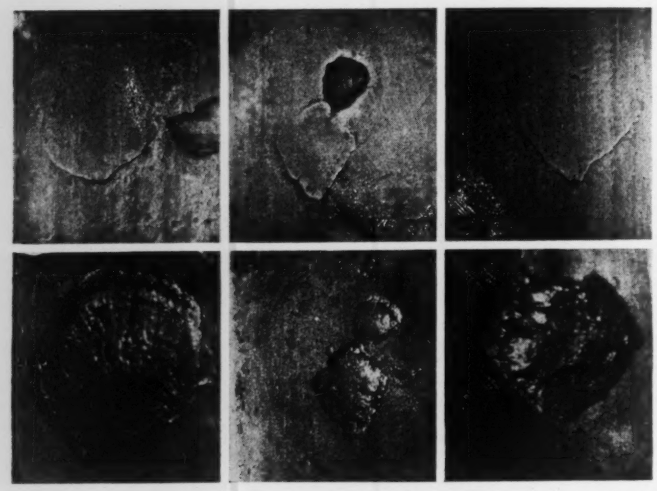


Fig. 8—Initial cracks and subsequent fan-shaped pits on rollers. Magnification 11X

Location of the start of the surface fatigue cracks is of importance in throwing light on the stresses responsible for the failure.

Consider the stresses that exist in a cylindrical body in contact with another. Let the width of the contact area be 2 *b*. If the bodies are perfect cylinders and the tangential forces in the contact area are distributed as a semi-ellipse:

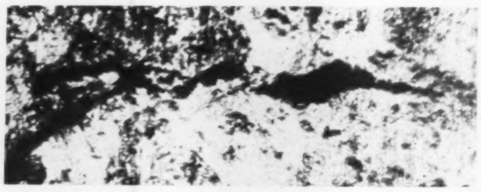


Fig. 9—Appearance of ball bearing race failure. Magnification 136X

$$P = P_{max.} \sqrt{1 - \frac{y^2}{b^2}}$$

where y is the distance from the center of the contact area. The maximum shearing stress, which is found at depth $0.786b$ below the surface, is of magnitude $0.300P_{max}$, and acts on planes making angles of 45 degrees with the surface and parallel to the contact bond. When the cylinders are rolling, the greatest variation in shearing stress occurs on a horizontal plane at depth 0.500 *b*, and varies from $+0.25\ P_{max}$ to $—0.25\ P_{max}$.

From the standpoint of fatigue one might guess that the material at depth 0.500 *b* is in the most severely stressed condition. To study this matter experimentally, the following tests were made. Steel cylinders 1½ inches in diameter, approximately, were given a good polish with fine emery paper and alumina powder. These rollers were run together in pure rolling contact with normal pressure. The material was quenched and tempered 0.40 per cent carbon steel of 240 VPN hardness, which has a shearing endurance limit of about 32,000 pounds per square inch. Loads were used in successive tests making P_{max} 165,000 and 202,000, and the reversed shearing stress 40,200 and 50,500

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* *S. Timoshenko, Theory of Elasticity, p.* 344.

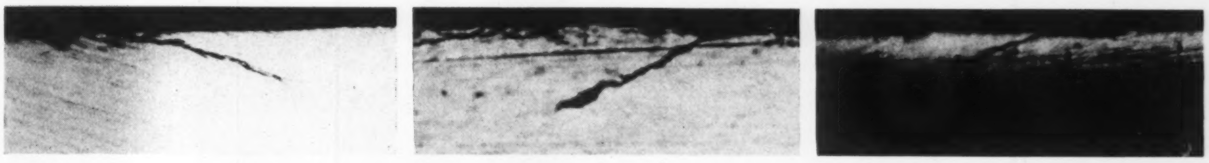
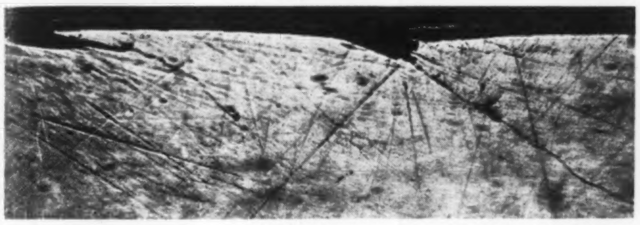


Fig. 10—Above—Surface cracks on roller (340X) at left, on ball bearing race (680X) in center, and on roller bearing race (340X) at right. Fig. 11—Below—Development of crack on gear tooth. Magnification 140X



pounds per square inch. Over 8.5 million cycles were run in each test. At the end of the test at higher load there was no sign of pitting. Later, one of these rollers was sectioned to see if any fatigue cracks had developed in the region at depth 0.500 *b*. None were found even though the reversed shearing stress was 55 per cent above the shear endurance limit. It would appear that a very high alternating shearing stress below the surface in a region of high hydrostatic compression is not necessarily dangerous as far as fatigue is concerned.

It was found that if rollers of the material just discussed were given a ground finish, instead of being polished, pitting would take place at a load of about 85,000 pounds per square inch for P_{max}. In this case the theoretical reversed shearing stress below the surface is only 21,200 pounds per square inch, which is below the shear endurance limit. By studying the cracks in section it is found that they start much closer to the surface than 0.500 *b*. We are thus led to the belief that pitting fatigue cracks are not due to the theoretical Hertz stress system for smooth cylinders, but to the stresses due to the contact of the waves and protuberances on surfaces of rolling bodies.

Cracks have been observed in section extending less than .001 inch below the surface. It is not certain whether these cracks start at the surface or somewhere below the surface in the layer .001 inch thick. However the experiment with the polished rollers is indication that cracks do not start below the surface.

Effect of Oil on Crack

Imagine two rough cylinders in contact. The contact area will not be the theoretical band of width 2 *b*, but will be a series of island areas. We have spoken already of the tensile stress at the surface and the possibility of fatigue failure starting at the surface in the case of circular and elliptical contact areas, in connection with the pitting of ball bearings. The roughness of the surfaces of the cylinders is responsible, therefore, for stresses that might cause failure to start at the surface.

If cylindrical rollers be run together without oil, and with pure rolling contact, the wear will be negligible but the surfaces will become oxidized. If oil is added after several million cycles have been run at a load above the pitting endurance limit, pitting will take place in a short time. This indicates that small fatigue cracks were present in the unlubricated rollers, which did not grow to serious proportions until oil was added.

An explanation of these phenomena, and of the fact that all mature pitting cracks are observed to slope into the surface in the same direction, is furnished by the hypothesis that the oil enters the fine fatigue cracks and, by the virtue of the presence of the approaching opposite roller, becomes trapped in those which are favorably oriented. The pressure in the oil so trapped might well reach a gigantic value and cause the crack to be driven deeper into the metal.

Methods to Minimize Fatigue

Observations of surface pitting mentioned above enable conclusions to be drawn as to the direction in which we should look to discover ways of minimizing surface fatigue. First, the failures are recognizable as fatigue failures, and this means that materials of sufficiently high endurance limits should be used to prevent them. Aside from increasing the strength of the material, the only way to avoid failures is to reduce the stresses. For parts in danger of surface fatigue, this can be done in several ways. Assuming the total load applied in the contact area is given, the stresses resulting from the load application can be reduced by using

(1) Smaller surface curvatures to reduce the contact stresses in and around the contact area

(2) Material of low modulus of elasticity which causes a wider distribution of the load and lower contact pressures

(3) Smoother, more accurately finished surfaces to avoid concentrations of load on bumps and high spots

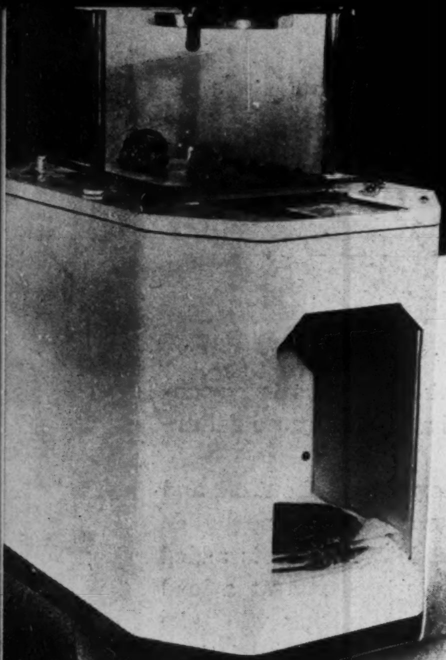
(4) Lubricant of sufficiently high viscosity to relieve the concentrated pressures on surface high spots.

To know the relation of factors such as surface curvatures, modulus of elasticity, surface finish and lubricant properties to the endurance limit required for rolling bodies to be free from surface fatigue, test data must be obtained under controlled conditions.

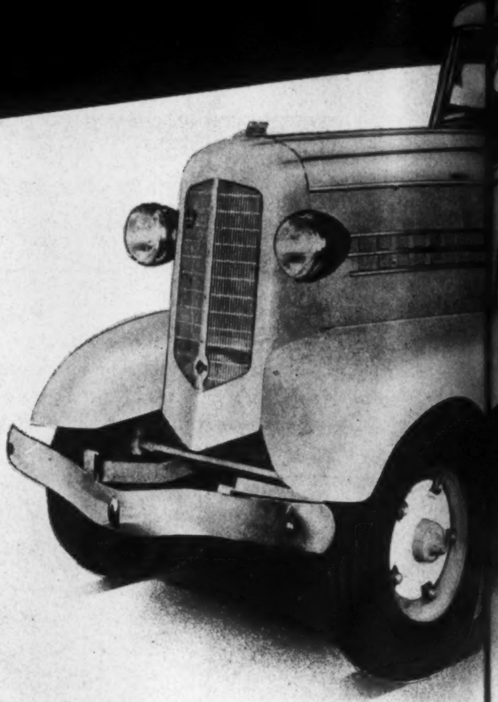
Design Featu
In New Machi

A Pictorial Presentation of Recent
chinery from the Standpoint of D

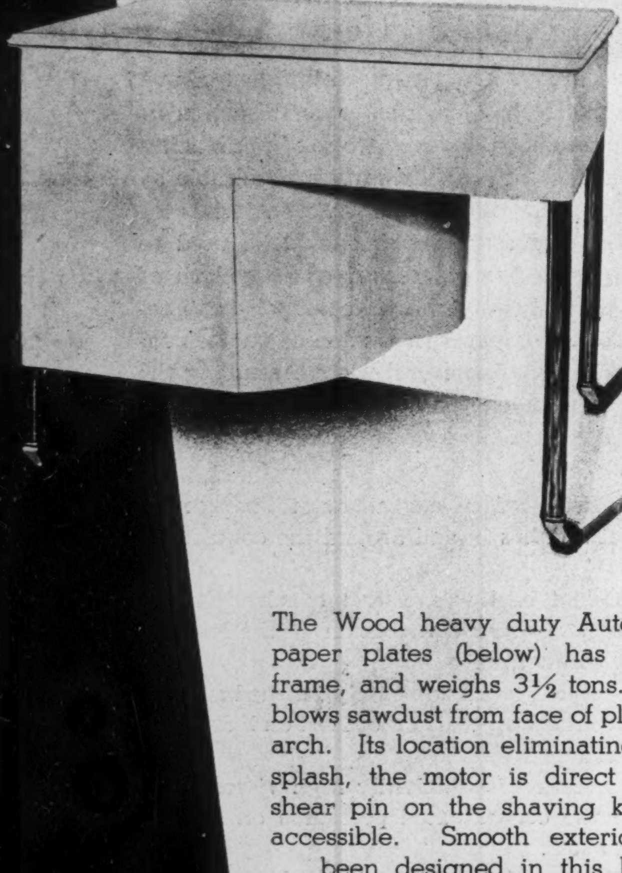
(For new machine listing see page 86)

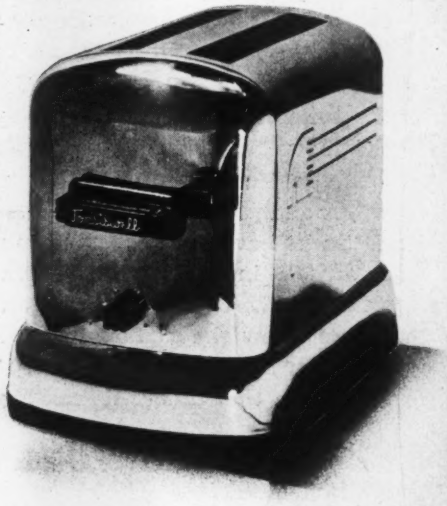


Proper timing and automatic positive operation of all correlated parts in the Holly hamburger patty maker (left), constituted a notable design problem. The transparent mold lining sheet seen at top is pulled under the mold head on each downward stroke and brings up the completed patty with an underlying portion of wax paper. Paper is cut, trap doors open and the patty drops into the hopper at the front of the machine. Case is baked white enamel, moving parts are chromium plated



A washing machine has been incorporated in a kitchen table in the Voss Kitchen Table Washer (below). Cradle of machine permits wringer to be folded down into rinse tub so the table top may be placed in proper position. The washer is finished throughout in smooth hard baked enamel except for chromium-plated legs. Controls are convenient, drive is sealed





An acc
clock
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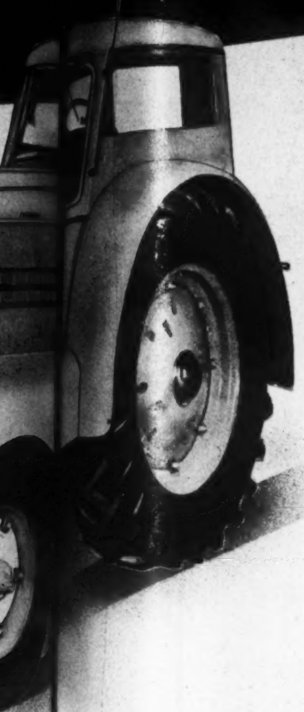
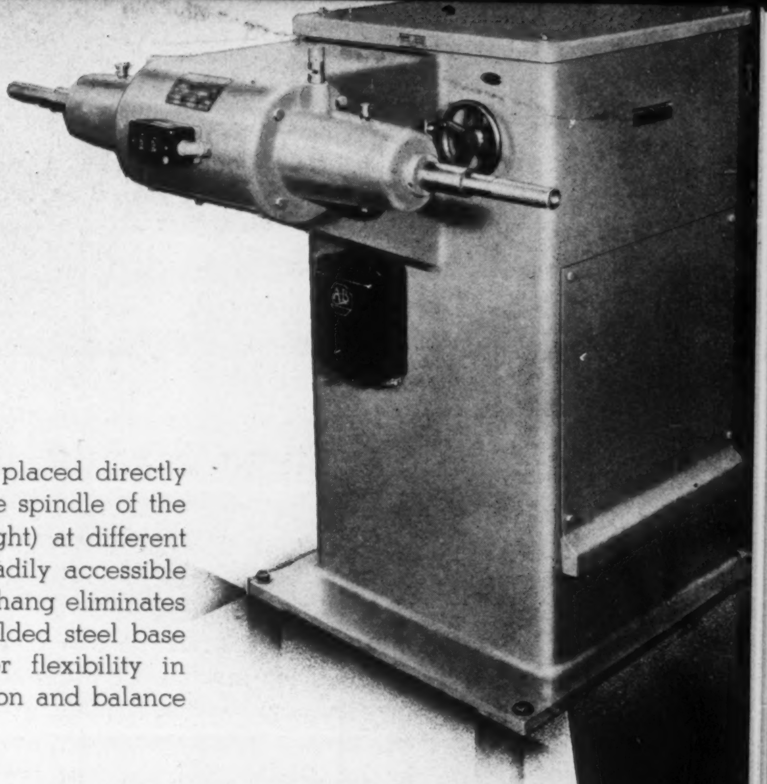
Automatic time control, consisting of a time clock and a thermostat, shortens the toasting period on the Utility Toastswell automatic toaster (above) as it warms up. A selective automatic lift permits adjustment so the toast will be raised a short distance and remain hot or will be raised half-way out of the toaster. Finish is chromium, handles and feet are plastic

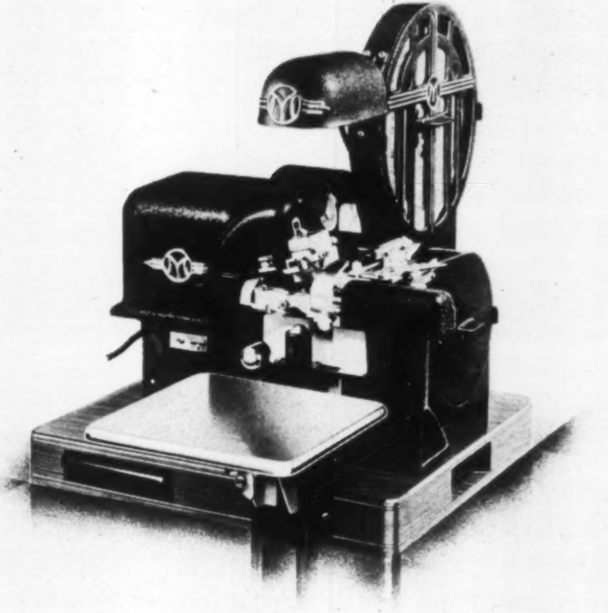
The Wood heavy duty Autoshaver for newspaper plates (below) has a one-piece cast frame, and weighs 3½ tons. Compressed air blows sawdust from face of plate as it enters the arch. Its location eliminating danger of water splash, the motor is direct connected. The shear pin on the shaving knife bar is easily accessible. Smooth exterior contours have been designed in this large machine



Cab of the Minneapolis-Moline Comfortractor (left) is all-steel with safety glass throughout. Transmission offers five speeds forward, one reverse. Entire inner portion of transmission is protected against dirt by felt seals, with leather seals retaining oil. Variable speed flyball type governor is fully enclosed, lubricated by engine oiling system, pedal-controlled



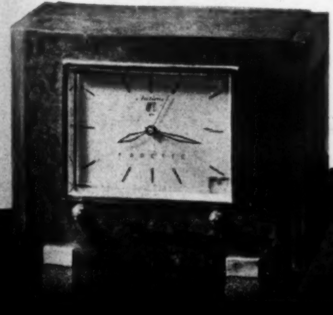
Built-in variable sheaves, placed directly above the motor, drive the spindle of the Crown polishing lathe (right) at different speeds. All parts are readily accessible for inspection. Long overhang eliminates wrench adjustments. Welded steel base is said to permit greater flexibility in attaining weight distribution and balance

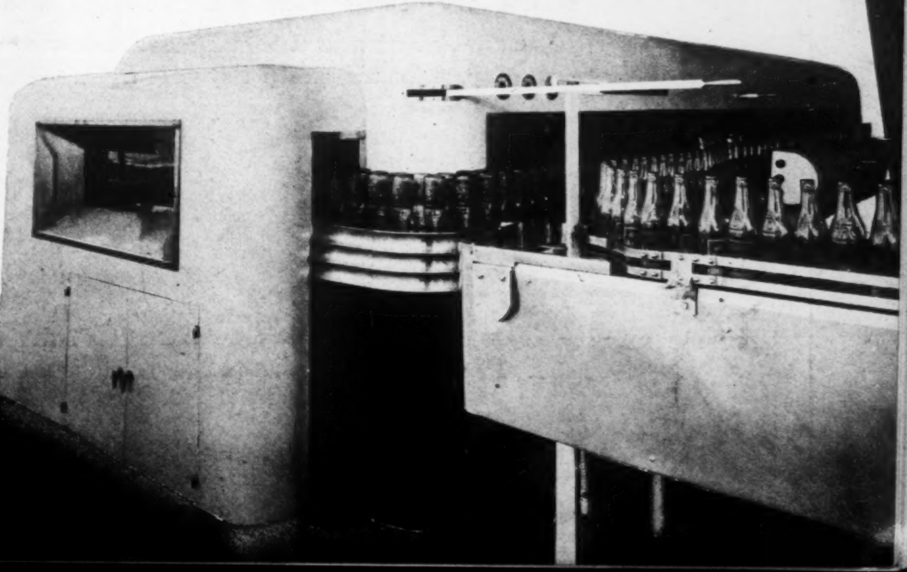


An entirely enclosed cam mechanism driven through a worm gear speed reducing unit by a one-twentieth horsepower motor is the key to operation of the Monarch Pin-On machine (left). It feeds special plated pins by extracting them from a paper strip and then drives them through price tag tickets in a manner which does not snag merchandise or harm hands. Finish of the machine is black crackle with all exposed parts except the covers in chromium

Start and stop motion of the Miller-Hydro bottle washer and sterilizer (below) must be exact and is accomplished by a drive that moves the chain of cups to a predetermined distance and locks. To eliminate splashing of hot alkali bottle-cleansing solutions, Barnes & Reinecke, industrial stylists, designed a housing completely enclosing the machinery with three plate glass windows on the side permitting a clear view of the operation. Sections were designed for ease of fabrication and interchangeability. Black and white portions are baked enamel. Horsepower consumption was reduced 50 per cent through installation of centrifugal pumps

An accurate alternating current electric clock and a standard broadcast radio have been built into the International Autime radio alarm, (below). The radio turns on and off automatically at any preset time. Simple, attractive cabinet is finished in burl walnut





Steps Should Be Taken to Reduce Engineering Unemployment

ESTIMATES indicate that upwards of fifty per cent of the country's engineering graduates are not engaged in engineering work; further, that a large proportion of these, about sixty per cent, cannot find employment of any kind. These figures apply, of course, to the depression period but, as stated by Dr. D. B. Steinman, past president of the Society of Professional Engineers, ". . . . . in normal times there are plenty of recent graduates begging for jobs in engineering offices, even without salary!"

As long as such conditions obtain, whether in normal times or depressions, the profession of engineering cannot hope to attain the high level to which it is entitled. Nor will salaries reach, or be maintained at, a point commensurate with the hard work and years of training required in the development of successful engineers.

One basic reason that accounts for the current unemployment among engineers, and for the fact that many have been compelled to seek other types of work, is overcrowding. Starting with the graduates of technical high schools who wish to follow engineering, right through to the students taking postgraduate courses, far too many men seem to feel that engineering holds unlimited promise. This attitude unquestionably is fostered by the romantic writings that appear from time to time fallaciously picturing the work of engineers and entirely minimizing the years of concentrated labor and effort that have gone before.

It's high time that a more practical attitude toward engineering be adopted by all. We have a host of good engineering schools and it is hoped these will maintain a reasonably high enrollment rate. But whether as many graduates should be turned out from these schools is another matter, particularly if all the graduates really expect to make a successful living. Yet an engineering education fits a man for progress in later life, generally speaking, as well as any other course. So perhaps it would be unfair—even unwise—to try to limit enrollment as do some of the other professions. At the same time, requirements for graduation might well be stiffened considerably, and thus a higher percentage of graduates turned out whose aptitude and acquired qualifications might lead them to believe they will find satisfactory openings in their chosen profession.

Only by action of this or similar nature can engineers expect to attain the respect, prestige and prosperity that rightly are theirs!

Professional Viewpoints

MACHINE DESIGN WELCOMES LETTERS SUITABLE FOR PUBLICATION

Commends Thermal Stress Article

To the Editor:

MR. SHEPHERD'S article "Why Thermal Stresses Cause Failure of Parts", in your February issue, page 47, should be of particular value to MACHINE DESIGN'S readers because it discusses qualitatively the mechanism of heat failures and does not obscure the physical picture by introducing involved mathematics. A conceptual knowledge of heat stresses is indispensable to the satisfactory design of parts which have to withstand both mechanical and thermal forces.

The author points out that ribs should be designed for heat dissipation and not for strength. In line with this thought the machine designer should avoid the use of nonuniform sections for parts required to transfer heat, since these heat dams always result in a stagnation of flow and cause excessive gradients conducive to failure. The failure of parts exposed to the working fluid of an internal combustion engine in many cases can be attributed to the presence of such heat dams.

Fluctuation of the boundary temperature (G. Eichelberg, FORSCHUNGSARBEITEN, No. 263, 1923) has been shown to be a small percentage of the fluctuation of the gas temperature in the cylinder. Furthermore, this fluctuation is inversely proportional to the square root of the frequency, so that the cyclic thermal stresses in a moderate or high speed internal combustion engine are not as important as those due to the mean gradient.

In regard to suitable materials, the manufacturer of an aircooled outboard motor has solved this problem by the use of die castings. The success of the design shows that some die cast materials have favorable thermal properties in this particular application.

—K. E. BISSHOPP
Beloit, Wis.

Art and Styling—Mutual Influences

To the Editor:

AS AN interesting side light which has occurred to me and which might prove to be a good subject for discussion, I have noticed that the machine affects art and architecture to a considerable degree and on the other hand that present designs of machines are influenced by artistic and architectural considerations. It may be that places are being exchanged and the artists of today will become the machine designers of tomorrow, with machine designers of today the artists of tomorrow. At any rate we machine designers are concealing the gears, links, and other moving machine members, whereas the so-called modern art seems to like the idea of dumping these in a pile and depicting them thus in their paintings!

—R. S. ELBERTY
Landis Tool Co.

Raises Question on Invisible Glass

To the Editor:

THE article on "invisible" glass on the Topics page (26) of your February issue has me stumped. I read a similar article . . . and did not agree with the theory expressed . . . I am beginning to wonder just what the truth of the matter is.

Your explanation that the light reflected from the front of the film and that reflected from the rear side of the film, (the front surface of the glass) becomes invisible when reflected because the components are out of phase, sounds perfectly logical. The fact that this reflected light is invisible to an observer, however, seems to have no bearing on the question of how much light will be transmitted through the glass.

Would not a more logical explanation be that the amount of visible light reflected toward an observer is decreased from 25 per cent to less than one per cent, thereby rendering the surface of the glass practically invisible, while the amount of light actually passing through the glass is the same as before, 75 per cent, or perhaps slightly less than this because of the losses of light in passing through the film?

My interest in this matter is largely academic and I do not know anything about the glass except the description . . . However, I would appreciate it if you could set me straight on this matter.

H. A. WILCOX
Automatic Signal Corp.

Editor's Note: Other questions have been asked regarding the manner in which the films eliminate reflection. These will be correlated and the answer published next month.

Men of Machines

HIS extensive knowledge of the automotive industry gained through his various connections as designer and chief engineer of automobile companies will be valuable to David E. Anderson in his new position as research engineer of Holley Carburetor Co.

Prior to his last connection as chief engineer of Bohn Aluminum Brass Corp., Mr. Anderson's experience included design work with Wisconsin Motor Co., A. C. Clark Co. and Brush Runabout Co. Later he transferred to U. S. Motors Corp. as assistant division engineer. As chief engineer he then joined Falls Machine Co., and later became designer with Cadillac Motor Car Co. In 1916 he joined Essex Motors as designer, later becoming assistant chief engineer. He afterwards returned to Cadillac company as engine designer, remaining until 1926 when he joined Bohn Aluminum.

DAVID E. ANDERSON

TAKING a prominent part in the engineering curriculum of Carnegie Institute of Technology, Pittsburgh, Dr. Webster N. Jones, who came to the institute in 1932 following a teaching and industrial career, has been elected president of the American Institute of Chemical Engineers.

Dr. Jones received his A. B. and M. A. degrees from the University of Missouri, and later, his Ph. D. from Harvard. His professional career, from 1908-1919, includes teaching at the universities of Purdue, Harvard, Maine, Missouri, Montana, and Radcliffe college. Following the war, he joined the B. F. Goodrich Co. where he remained until becoming connected with Carnegie Institute in 1932 as director of the college of engineering. He has published numerous papers on technical subjects and on engineering education, as well as editing the Annual Survey of American Rubber Chemistry.

WEBSTER N. JONES

IN HIS new appointment as director of research and standards of American Machine & Foundry Co., U. A. Whitaker, formerly director of development and design of the Hoover Co., undertakes an assignment of broad nature. This involves design, cost estimating, manufacturing and patent department activities.

Graduating with a mechanical engineering degree in 1923 from Massachusetts Institute of Technology, and later obtaining one in electrical engineering from Carnegie Institute of Technology, Mr. Whitaker's first connection was with Westinghouse Air Brake Co. as special engineer. During his last two years with this organization he specialized in preliminary development and planning, and worked with the patent department in coordinating patent developments and engineering. He remained for seven

U. A. WHITAKER

3 "WAYS" *agree on* 1 FACT

MODERN METALS REDUCE OPERATING COSTS

RAILWAYS

General Motors' use of Nickel alloyed iron in Diesels for these Santa Fe streamliners cut weight per H.P. Nickel-chromium iron is tougher, retains strength at high temperatures, and wears longer.

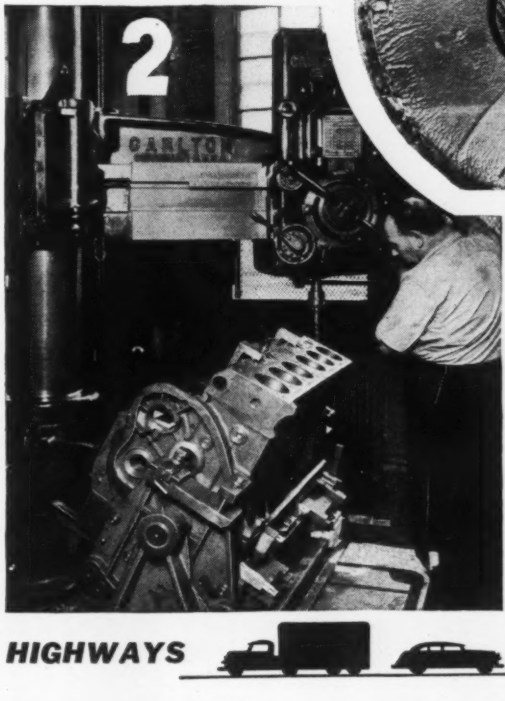
Railways, highways and waterways present varied operating problems. But each transport system agrees operating costs can be reduced by utilizing modern materials—such as Nickel alloyed cast irons.

For new equipment or replacement parts, take full advantage of the money-savings made possible by modern metallurgy and engineering. Make each ounce, each inch of metal carry bigger loads, resist harder wear, by specifying the correct alloy strengthened and toughened with Nickel.

WATERWAYS

2.391.860
CU. YDS
Ni-Hard Alloy
3

28-inch dredge liners used at Ft. Peck Dam. Under identical conditions the liner at left above, rolled from plain steel wore out after handling less than 1½ million cubic yards. The liner at right above cast from Ni-Hard—the abrasion-resistant Nickel iron—withstood 2-1/3 million yards and after inspection it was put back in service to add millions more yards to its career.*



Mack Mfg. Corp. casts these heavy duty truck cylinder blocks in their own foundry from Nickel alloyed iron. Nickel increases machinability, permits drilling at speeds 1½ times faster than in other irons of same hardness.

NICKEL CAST IRONS

HIGHWAYS

*Reg. U. S. Pat. Off. by The International Nickel Company, Inc., Canadian Patent No. 281986

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

years with this company. In 1929 Mr. Whitaker joined the Hoover Co. where, as director of development and design, he had charge of engineering and was again closely associated with the patent department, all patent drawings and engineering patent co-ordination being carried out under his direction.

◆

LOUIS M. GREENE has undertaken new duties in engineering supervision of both Pathe Engineering & Tool Mfg. Co., and its subsidiary, Multi-Needle Engineering Co.

◆

DELMAR G. ROOS has been named vice president in charge of engineering of Willys-Overland Motors Inc., Toledo, O.

◆

DR. PAUL L. SMITH has been reappointed for 1939 as research associate of the Porcelain Enamel institute. Associated with the National Bureau of Standards, Dr. Smith has been conducting technical research projects for the institute since his original appointment in 1937.

◆

A. J. GILLESPIE has been appointed assistant chief engineer of Thew Shovel Co. Simultaneously with this and other appointments the engineering department has been moved from Cleveland to Lorain, O.

◆

D. S. BRISBIN has been made president of Motor and Equipment Manufacturers' association. He is connected with Columbus-McKinnon Chain Corp. D. H. DASKAL, of Perfection Gear Co., was named vice president.

◆

R. LEE HOMSHER, formerly sales engineer for Allis-Chalmers Mfg. Co., has been named designing engineer for Kimberly-Clark Corp., Neenah, Wis.

◆

HAROLD H. STRAUS is now a member of the stress analysis department of the Northrop division of Douglas Aircraft Co., El Segundo, Calif.

◆

JOHN L. V. BONNEY JR. has become associated with the technical division of E. I. du Pont de Nemours & Co. Inc. He was formerly connected with the observation corps of Carnegie-Illinois Steel Corp.

◆

THOMAS R. MARTIN has transferred from Arthur G. McKee & Co., where he was equipment engineer, to Sawyer-Massey Ltd. as assistant chief engineer and assistant production manager.

◆

PROF. ALFRED V. DEFOREST, of Massachusetts Institute of Technology, has received the 1938 Sylvanus Albert Reed award for developing the "magnaflux" method of testing metals used in aircraft construction for flaws. The award was presented to Professor deForest at the annual honors dinner of the Institute of the Aeronautical Sciences.

◆

PROF. FRANK B. ROWLEY was recently awarded the American Society of Heating and Ventilating Engineer's medal for "distinguished scientific achievement in heating, ventilating and air conditioning" at the annual meeting of the society. Professor Rowley is director of engineering experiment station of the University of Minnesota.

◆

CHARLES B. BOHN was elected president of Aluminum association at its recent annual meeting. He is president of Bohn Aluminum & Brass Co.

◆

M. A. BELL has recently been made president of the Bell Machine Co. replacing the late E. J. BELL. Mr. Bell's practical engineering, sales and factory experience will be of assistance to him in his new position as president. He is a graduate of the University of Wisconsin and has been connected with the company for sixteen years.

◆

PAUL O. PIPPEL, formerly assistant manager of the patent department of International Harvester Co., has been advanced to general patent attorney for the company. Mr. Pippel replaces V. F. LASSAGNE who has retired from active service. R. D. ACTON has been promoted to succeed Mr. Pippel.

◆

DR. GEORGE W. LEWIS, director of research for the national advisory committee for aeronautics, Washington, has been elected president of the Institute of the Aeronautical Sciences, succeeding T. P. WRIGHT, director of engineering of Curtiss Wright Corp.

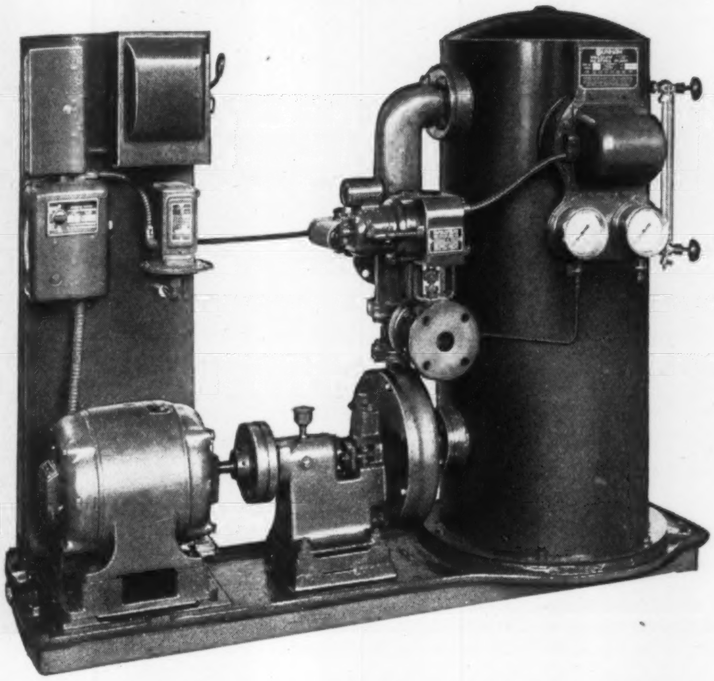
◆

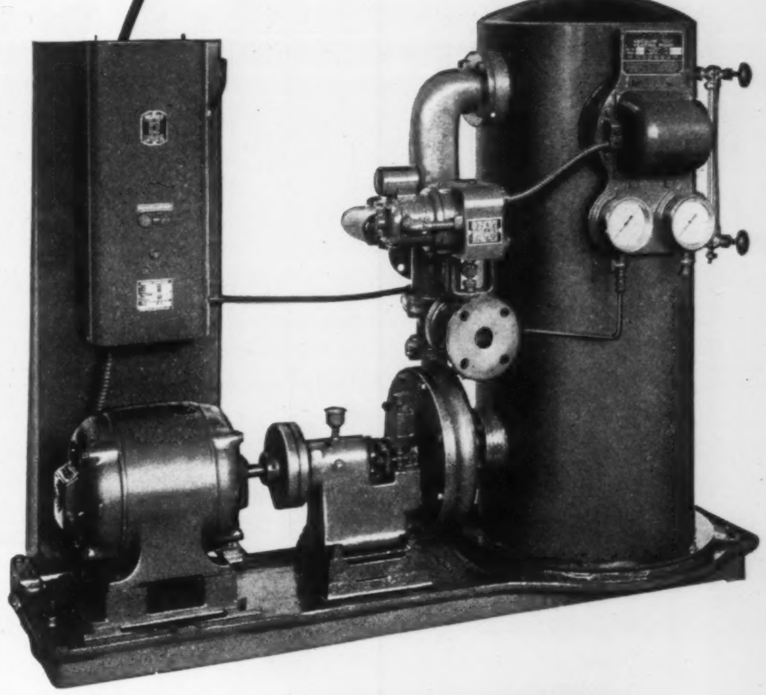
GEORGE F. WALES has resigned as chief engineer of the stamping plant of American Radiator Co., in which capacity he had been for the past fifteen years, to devote his entire time to the industrial product design and management of the Strippit Corp., Buffalo, of which he is president and founder.

◆

F. L. PIERCE, formerly staff engineer of the Hoover Co., has been placed in charge of engineering, working closely with the patent department of the company. Mr. Pierce, a mechanical engineering graduate of the University of Michigan in 1926, has been with the Hoover Co. since that time, except for brief connections with General Motors and Asbestos Mfg. Co. He progressed through the laboratories to the head of the mechanical section, to staff engineer, and later senior staff engineer.

Unified
MOTOR CONTROL



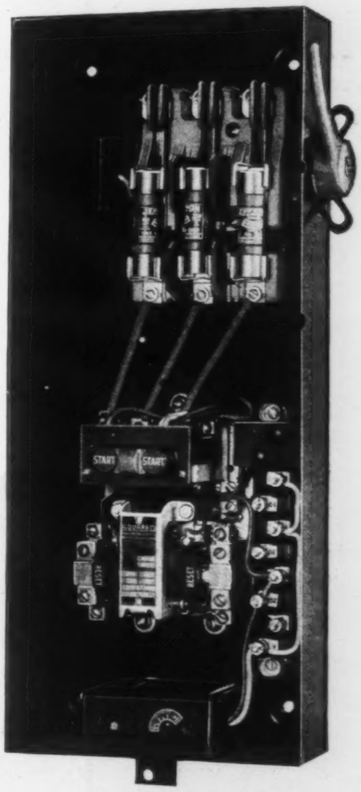


● The pictures present a striking "before and after" story. The former control for this vacuum pump consisted of a disconnect switch, a vacuum regulator, an automatic motor starter, and a terminal box—four units, of different manufacture, to be mounted separately and connected separately.

The new equipment is Square D Unified Control. Square D manufactures all of the required units and can mount them in a single enclosing cabinet. The advantages are obvious. A neater and more compact control assembly; all internal wiring done by the control manufacturer; no greater cost for the apparatus; lower cost for installation; and a guarantee of all units by the Square D Company.

Square D builds unified control for many applications. Switches and automatic starters in combination with pressure, vacuum and float switches and with temperature control.

You can improve the utility, economy and sales appeal of your equipment by changing to Square D Unified Control.



Square D Unified Motor Control

CALL IN A SQUARE D MAN

SQUARE D COMPANY

DETROIT - MILWAUKEE - LOS ANGELES

IN CANADA: SQUARE D COMPANY CANADA LIMITED, TORONTO, ONTARIO

ASSETS *to a* BOOKCASE

Engineers' Manual

By Ralph G. Hudson; published by John Wiley & Sons, Inc., New York; available through MACHINE DESIGN *for* $2.75 *postpaid.*

This second edition of Hudson's Engineers' Manual contains revisions and extensions of all tables of physical constants, new steam tables, recomputations of conversion factors affected by the latest definition of the British thermal unit, an enlarged table of conversion factors and other useful additions throughout the book. Also, the entire chapter on heat and a large part of the chapter on electricity have been rewritten.

Useful to practising engineers, it presents in systematic order the definitions, symbology, constants, tables and formulas in such a way as to be quickly and accurately applied. Catchwords, symbols and formulas are printed in full face type. Problems are included to show applications of principles discussed.

Mathematics is summarized in the first section and includes definitions and derivations for the application of algebra, trigonometry, analytic geometry, calculus, differential equations, vectors and hyperbolic functions. The section on mechanics includes kinematics, relations of mass and space, kinetics, statics and properties of materials with tables for standard shapes and forms.

Hydraulics covers definitions and basic formulas for hydrostatics, hydrodynamics, wiers and jets. A chapter on heat discusses gases, liquids, vapors and their applications to air compressors, engines, and refrigeration. In the chapter on electricity are included magnetism; electrostatics; direct, transient, and alternating currents; and the principles of electrical machinery and power transmission.

□ □ □

Thermodynamics, Fluid Flow and Heat Transmission

By Huber O. Croft, published by McGraw-Hill Book Co. Inc., New York; available through MACHINE DESIGN *for* $3.50 *postpaid.*

Fundamental information useful to practitsing engineers embraces thermodynamics, dimensional analysis, fluid flow and heat transmission treated as one continuous subject. Of particular interest in this book is the complete discussion of dimensionally correct and empirical equations. An entire chapter is devoted to the theory of dimensional analysis, its uses in researches and its application to the derivation and testing of formulas.

Differential equations useful in energy equations, computations of vapor tables and other forms are discussed. Interrelations of solid-liquid-vapor phases of fluids are treated with the aid of charts and differential equations for several methods of approach. Computation of maximum available energy from the Carnot cycle is discussed as a measurement for efficiencies of practical cycles.

The same method of approach is used in calculating heat exchanger problems. Heat balance of internal combustion engines is also calculated in this way and compared with calculations using the first law of thermodynamics. The same approach is made for steam power plants, vapor cycles and steam turbines.

Friction losses in the flow of fluids are computed for various conditions of liquid flow and gases. Tables and charts show the variations in friction factors for pipes of different diameters and materials.

A chapter on heat transmissions includes radiation characteristics of various materials, liquids, gases and flames. Also conduction and convection are discussed with characteristics and formulas. Tables contain critical constants, average heat capacities, variations in viscosity of various liquids and gases for temperature changes.

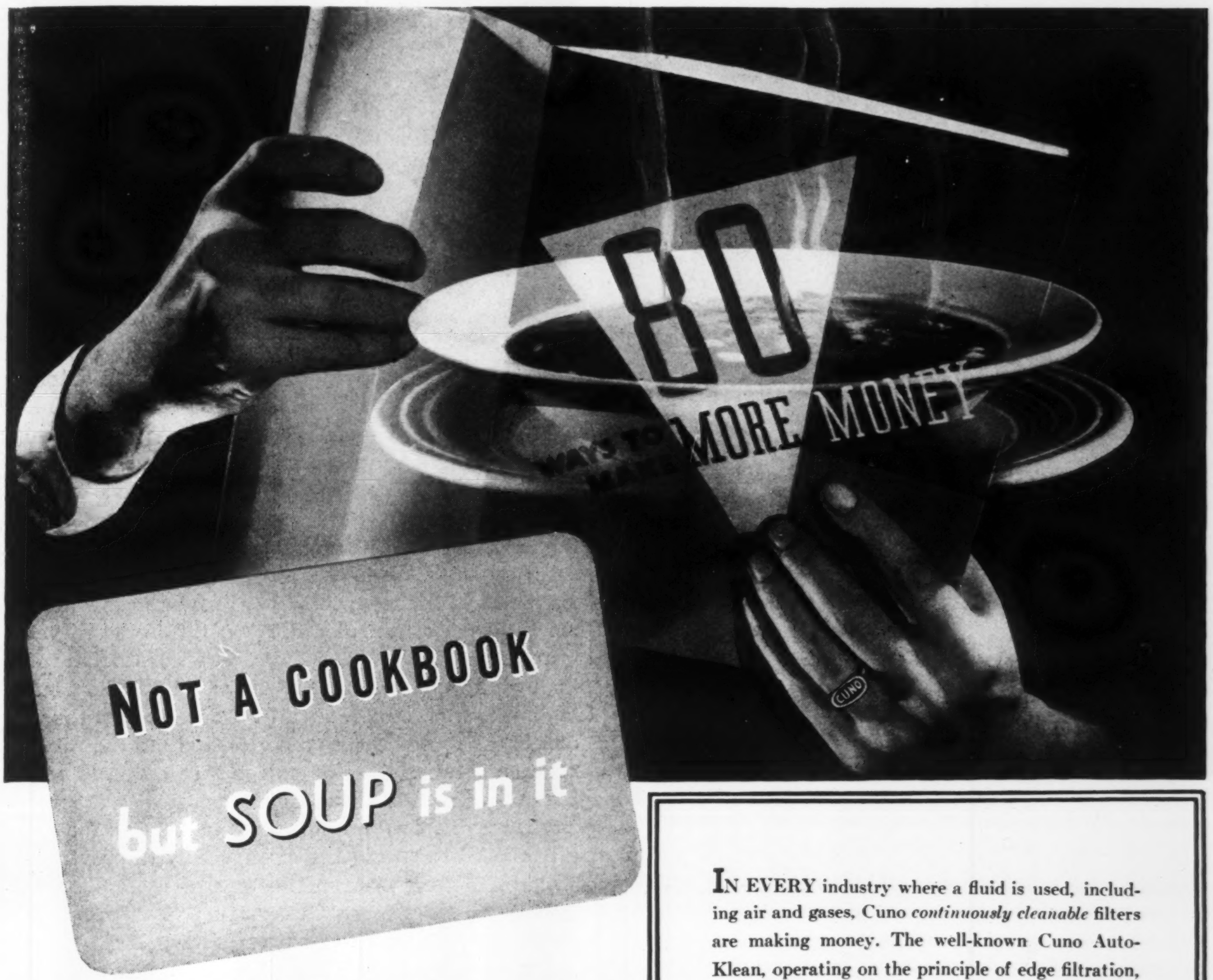
□ □ □

U. S. S. Carilloy Steels

Published by Carnegie Illinois Steel Corp., Pittsburgh and Chicago; available through MACHINE DESIGN *for* $1.00 *postpaid.*

Hardening of steel, based on practical and fundamental behaviors, discussed from recent findings. This handbook on alloy steels contains a list of steel making elements, their commercial uses, their effect in steel and the types of steel containing them. Analyses of S. A. E. alloy steels are included together with some of their commercial applications.

Chapters discuss the iron carbon diagram and its use for hardening and annealing operations, heating practice and heating furnaces for hardening and annealing, and quenching practice and the physical properties of different grades of alloy steels after quenching in various ways. The book is illustrated with many charts, some of which have not been published heretofore.



Here's a book that's so downright interesting, you'll take it home to read. It's the adventure of Cuno in your industry (and in many others) successfully adapting Cuno *continuously cleanable* filters to all kinds of jobs. Even soup.

Here's an epochal story of progress in engineering . . . of a new kind of filtering efficiency for you . . . of a new way for *you* to save money. Look over the 75 fluids Cuno is now straining . . . all the way from Acetone and Air to Water and Wax . . . and *continuously*. Old fashioned stop and go filtration is avoided. Think man, how you can use Cuno. The book is free. Use the coupon below.

IN EVERY industry where a fluid is used, including air and gases, Cuno *continuously cleanable* filters are making money. The well-known Cuno Auto-Klean, operating on the principle of edge filtration, permits positive mechanical cleaning of the filter element in one quick revolution — without interruption of the flow. Other members of the Cuno family, also continuously cleanable, are especially designed for the removal of extremely fine particles (as small as .001″) and highly abrasive solids. Protection is continuous. No duplex installations. Nothing to do but install — and run. And they are made to your own private requirements. One or a thousand gallons an hour. Name your conditions.

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263 South Vine Street
Meriden, Connecticut
Please send me, free, "80 Ways to Make More Money."
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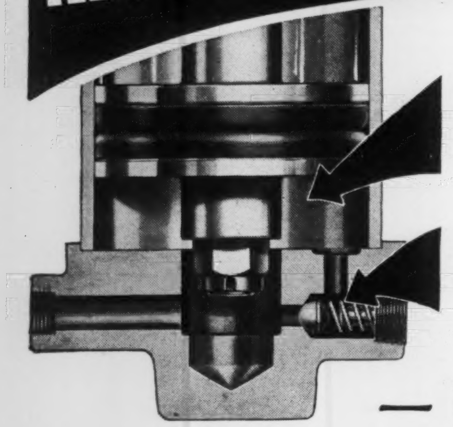
avoid stop and go with CUNO *Filters*

CUNO ENGINEERING CORPORATION ★ MERIDEN, CONNECTICUT

NOW WRITE *Cushioned* IN ALL AIR CYLINDER "SPECS"



New Non-Adjustable **Air Cushion by NOPAK eliminates need for non-cushioned cylinders.**

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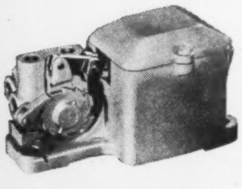
Quick-Opening **Air Duct assures swift, smooth cylinder action on every stroke.**

— Give Your Machines New Smoothness

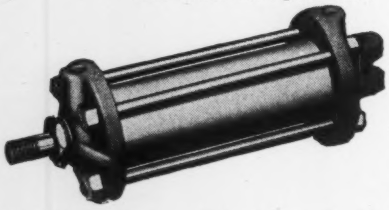
Instead of specifying "cushioned" or "non-cushioned" cylinders, simply specify NOPAK Cushioned Air Cylinders in one of these types:

- **New type NOPAK Cushioned Air Cylinders with *Non-Adjustable* Cushion-Heads. They eliminate the noisy, damaging metal-to-metal impact of non-cushioned cylinders . . . yet sell in the *same* price range.**
- **Standard type cushioned air cylinders with *adjustable* Cushion-Heads*. . . where close regulation of "cushion effect" at end of piston stroke is required.**

Either type assures smooth, efficient, trouble-free performance of air powered equipment, prolonged life for pistons and cup-leathers, lower maintenance cost for the entire cylinder assembly. Both types have Special Composition Cup Packing and extra-wide piston bearing to protect cups from excessive wear and friction. Write for bulletin.



For positive control, specify famous patented NOPAK Air Operating Valves . . . Lever, Foot and Solenoid operated.



NOPAK Non-Adjustable Cushioned Air Cylinder with Pendulum Mounting. Made in all Standard Mountings.

GALLAND-HENNING MFG. CO.

2752 South 31st Street • Milwaukee, Wisconsin

NOPAK VALVES and CYLINDERS

A 2490-½

Noteworthy Patents

Disk Brakes Are Self-Energizing

A RADICAL departure from conventional automobile brakes has been designed to provide relatively large braking areas together with self-energizing action. Vincent Bendix has assigned patent No. 2,140,731 covering this brake to Bendix Aviation Corp. In the brake, stresses are equalized within the assembly without any axial thrust.

On applying the brake, torque on the shaft with a universal joint shown in *Fig.* 1 turns a gear which is meshed with an annular rack on the inside movable brake shoe. The outside shoe is prevented from turning by a key between its flange and the spindle mounting but is free to move axially. Cams between the two disk shoes spread them proportionately to the relative rotation between them to engage with the faces of the brake housing. This housing is integral with the wheel and transmits the braking action to it. Thus the cams are enabled to spread the disks axially to provide the required braking pressure.

The two faces and disk construction distribute the pressure more evenly and over greater areas than is possible in conventional designs. Leaf springs between the shoes keep the cams in engagement and the disks free when the brakes are not in operation.

Self-energizing action is provided after braking has been initiated by the friction drag between the shoe and housing. This drag, in the direction of wheel rotation, is in the same direction as the initiating action and tends to increase the cam action and braking force.

The brake disks are entirely enclosed within the

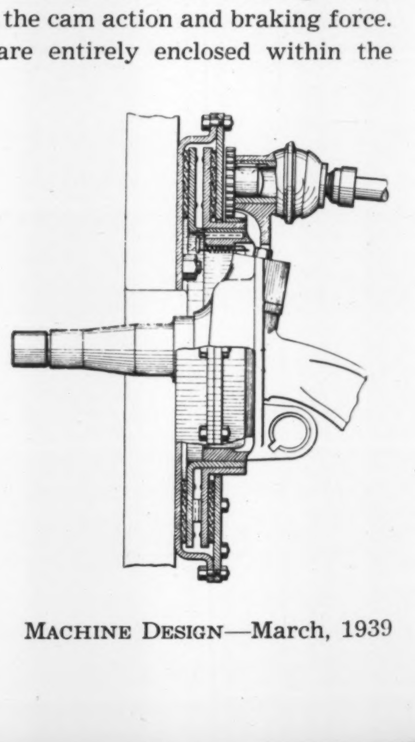
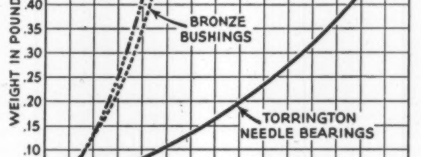


Fig. 1 — Self-energizing disk brake distributes pressure evenly over large area

COMPARE THE WEIGHT

of the TORRINGTON Needle Bearing

NOTE from the accompanying graph the lighter weight of the Torrington Needle Bearing, compared with ball bearings and bronze bushings of the same radial load capacity. The values selected are typical; similar savings in weight are obtained at other speeds.



NOTE: Bronze Bushings to have same over-all dimensions as Needle Bearings

Translate these savings in weight into terms of your finished product. When you consider that the use of Torrington Needle Bearings may save many ounces on even as small a unit as a portable tool, you will appreciate the full importance of this single feature.

And note, too, that the lower weight of the Needle Bearing is only a part of the total saving in weight. Small in size and compact in design, the Needle Bearing helps you to reduce weight in other parts of your design as well, because it allows you to use a very simple form of housing.

Unit Cost is Low

You can obtain these weight-saving advantages at very low cost. The Needle Bearing itself is surprisingly inexpensive in proportion to its capacity. Assembly cost is low, too; the bearing can be quickly pressed into the housing with a minimum of labor.

The efficient operation of the Needle Bearing means customer satisfaction, for it offers all the advantages of anti-friction construction and needs little service attention. The hardened retaining shell, with its turned-in lips, forms a reservoir to hold ample quantities of grease or oil. The rotation of the needles constantly supplies lubricant to the rotating shaft.

Consider the advantages of the Needle Bearing in your product. The Torrington Engineering Department will cooperate with you in laying out applications. For further information, write for Catalog No. 9. For Needle Bearings to be used in heavier service, request Booklet 103X from our associate, Bantam Bearings Corporation, South Bend, Ind.

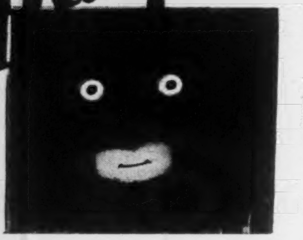
The Torrington Company
ESTABLISHED 1866
Torrington, Conn., U.S.A.

Makers of Ball and Needle Bearings

Branch Offices in all Principal Cities

TORRINGTON NEEDLE BEARING

Opaque-



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casing which excludes foreign matter that might be detrimental to the proper functioning of the brake. Adjustment for wear is readily made by advancing the gear rack with respect to the gear.

Propeller Design Dampens Vibration

AIRPLANE propellers driven from the center of percussion of each blade have been designed by Erle Martin. Assigned to United Aircraft Corp. and covered by patent 2,144,428 this propeller will not vibrate in resonance with the vibration frequency of the engine. Thus fatigue stresses are greatly reduced allowing for lighter and more durable blades.

In this design, the blades travel radially without any whip. As a result they are more efficient in operation. The blades are hollow (*Fig.* 2) with spider arms mounted integrally with the drive shaft and extending into the blades. At the center of percussion of each blade is a bearing through which the power is transmitted.

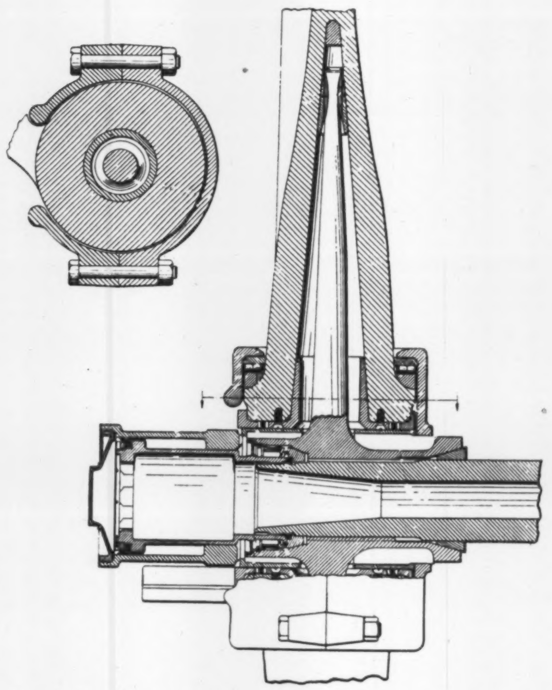


Fig. 2—Spider drives airplane propeller from center of percussion of blade

The base of the blade is mounted between antifriction bearings and rubber pads to provide a limited freedom between the propeller blade and spider. If the propeller should be slightly out of balance the resilience of the pad allows the parts to seek balanced position. In addition, this cushioned mounting tends to absorb any vibrational effects of the drive shaft. The properties of the pads are chosen so that the natural period of the propeller is below the rotational speed of the shaft. Likewise, the flexibility of the spider arm is adjusted to bring the period of the rotating mass below the frequency of vibrational effects in other directions.

Pitch of the blades is controlled by the hydraulic

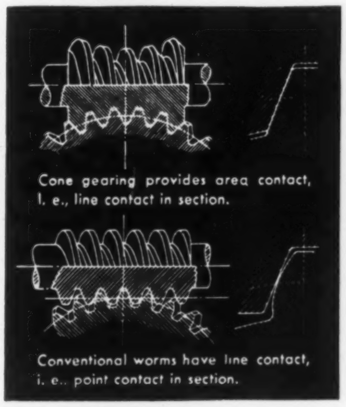
HALLIBURTON
OIL WELL
EWD
613
USUAL SIZE
CONE

5* TIMES The LOAD with CONE WORM GEARING

Five times the usual rating for worm gearing is what Cone Worms are called upon to transmit, day in and day out, in Halliburton's new portable 6,000 lb. pressure cement pumps in the oil fields. To make such pumps possible, the worm gear drive, delivering 110 hp. from the truck engine to the pump at 200 rpm. of the worm had to be held small enough and light enough to make the unit mountable on a truck.

The diagram above shows the comparison between the Cone gears used by Halliburton and the size that would have been required based on usual worm gear ratings.

The reason compact Cone gearing can carry higher loads is AREA CONTACT.


Cone gearing provides area contact, i. e., line contact in section.

Conventional worms have line contact, i. e., point contact in section.

CURRENT CONE OPERATING RANGES
Ratios......Low, 1 to 6; High, 150 to 1
Speed..Low, 1/15 rpm.; High, 30,000 rpm.
Sizes (C.D.) Low, 5/8 in.; High, 27½ in.

Cone worms and wheels are generated in such a manner that there is in continuous contact the entire depth and a substantial portion of the width of each worm and wheel tooth in engagement—and there are more teeth in engagement.

Further, lubrication is no problem with Cone gearing. Oil is 'pumped' through the contacting surfaces instead of being scraped off.

And finally, *both* worm and worm wheel tend to re-generate the original form. That is why Cone wheels and worms wear IN instead of OUT.

**Ordinarily Cone gearing is sold on a basis of about four times the usual mechanical rating for worm gears.*

MICHIGAN TOOL COMPANY, 7171 E. McNICHOLS RD., DETROIT, MICHIGAN

"9000–DD", with double Metal Seals, here shown; also made as "9000–D" with Single Metal Shield.

LARGER GREASE CAPACITY

NO SEAL DRAG

IN "9000" SERIES (Feltless)

SELF-SEALED BEARINGS

Interchangeable in dimensions with felt seal bearings.

Employs simplified, inwardly extending, flanged metal shields which do not rotate and cannot "foul" other rotating seal parts.

Seals are highly efficient in retaining grease in either horizontal or vertical position.

Simple seal occupies less space within bearing than felt seal, PROVIDING GREATER GREASE CAPACITY AND A MORE LASTING LUBRICANT SUPPLY.

Metal seals, though close fitting, clear recess on inner ring, ELIMINATING "DRAG" OR FRICTIONAL RESISTANCE and power loss, and providing higher starting speeds and increased efficiency. Seals cannot wear and are permanently effective.

Totally sealed against foreign matter, providing absolute cleanliness at all times.

"NORMA-HOFFMANN"
PRECISION BEARINGS
BALL, ROLLER AND THRUST

NORMA-HOFFMANN BEARINGS CORP'N.
STAMFORD, CONNECTICUT, U. S. A.

chamber shown at the left side of the hub. This chamber is operated through the hollow drive shaft. Below the chamber is a counterweighted arm on the blade, the centrifugal force of which tends to turn the blades to high pitch. Such an arm on each blade is connected to the piston so that its action may be regulated by the pressure in the hydraulic piston. The insert shows a section through the base of a blade and the arm for adjusting the pitch by blade rotation to the desired position.

Fluid Pump Employs Electromagnet

ADVANTAGEOUSLY employing vibrating diaphragms in suction, working and pressure chambers, the electric fluid pump shown in *Fig.* 3 automatically adjusts itself to throttling of fluid delivery. Designed by Georg Szekely, Germany, this invention is covered by patent 2,143,391.

Driving power is supplied by an electromagnet in the base. The core vibrates at the frequency of the alternating current supply. An adjustable spring of the same frequency at the bottom of the unit (not shown but similar to one on the pressure chamber) tends to return the core to a central position. At the other end of the core is connected a pulsating diaphragm which transmits the working effort to the fluid. This core is held central and the air gap kept constant by horizontally mounted springs above and below the electromagnet.

Above the working chamber are the suction and pressure chambers. Each contains a diaghragm with a vibrating period in resonance with the system and adjustable compression and extension springs respectively. This compensates for pulsing of the pump and

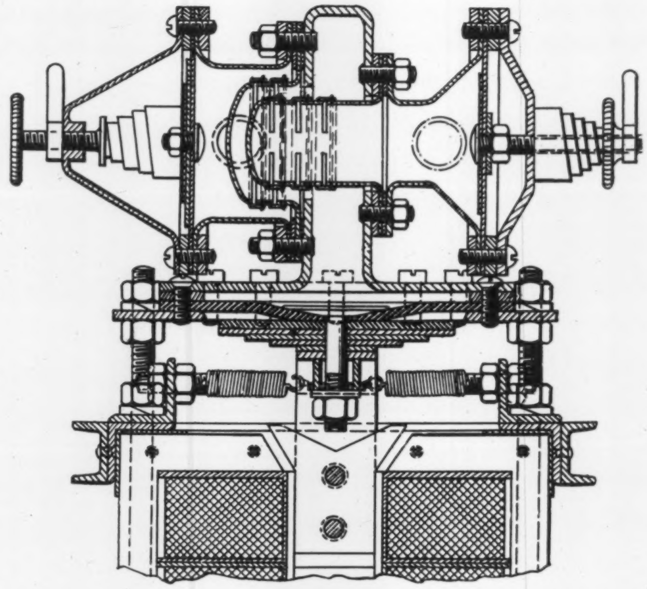
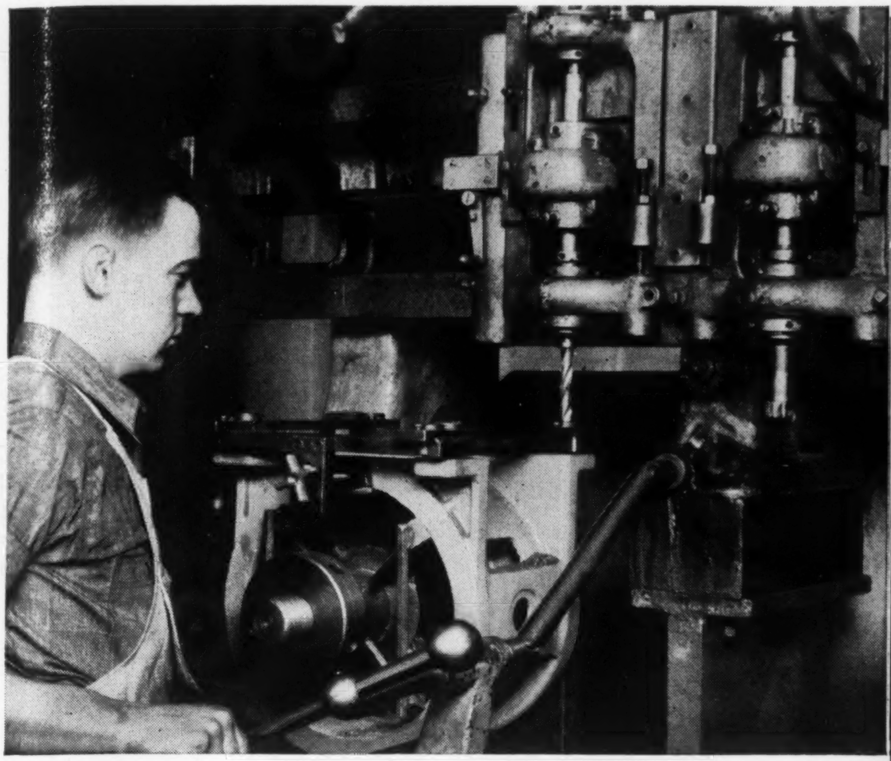
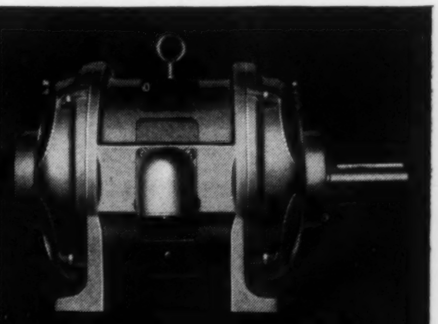
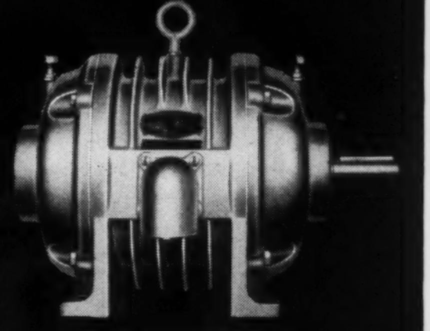


Fig. 3—Electromagnet vibrates diaphragm in pump according to requirements

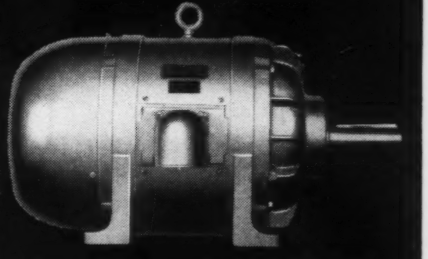




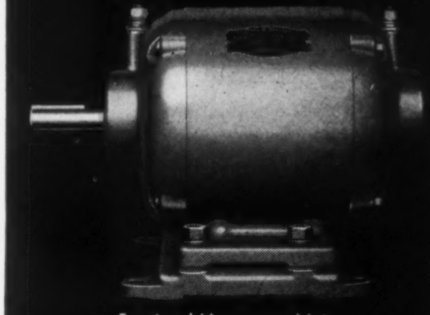
Open Frame, Sleeve or Ball Bearing



Totally Enclosed Ball Bearing



Totally Enclosed Fan-Cooled Ball Bearing



Fractional Horsepower Motor

• • •

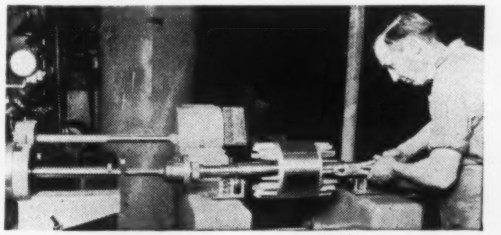
Delco industrial AC motors are available in various types, possessing electrical and mechanical characteristics to meet practically every requirement.

Normal starting torque—normal starting current—high starting torque—low starting current—as well as high slip. Each type available in open frame, sleeve or ball bearing—totally enclosed ball bearing—totally enclosed fan-cooled ball bearing—also multi-speed motors. Electrical and mechanical modifications available. Delco motors comply with NEMA standards.

MILLED AND DRILLED to give you better alignment

There is one characteristic of every step in the making of a Delco motor: As many operations as possible are done with one set-up, to insure absolute accuracy; and each machined surface is registered with every other machined surface.

Most operations are done on special machines, designed and built for the particular job, so that absolute uniformity of manufacture is maintained. For example, the rough main frame of a Delco motor is chucked through the stator opening; all four feet are milled to the same height, and in the same place; and the mounting holes are drilled—all in one set-up. This precision is typical of every operation at Delco Products. That is why we ask you to look *within* the motor you specify.



EVERY DELCO MOTOR IS DYNAMICALLY BALANCED

No motor leaves Delco Products that has not been dynamically balanced on a specially-designed balancing machine. Delco balances every motor. Each end of the rotor and shaft is first balanced independently, while the machine indicates exactly how much compensation is required and where it should be applied. After all adjustments have been made, the complete rotating assembly is given a final check. Delco motors assure satisfactory balance.

DELCO MOTORS

DELCO PRODUCTS • DAYTON OHIO

DIVISION OF GENERAL MOTORS CORPORATION

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Eclipse Moulded PLASTICS . . .

As a fitting companion for their sensational new "Torkflash" Tension Wrench, Blackhawk Manufacturing Company designers wisely chose a modern Eclipse Moulded Tool Box of Bakelite. The attractive, lustrous black box with its rich red cover is not only an additional merchandising help to Blackhawk, but is one of the many difficult and intricate jobs Eclipse designers and craftsmen do so well.

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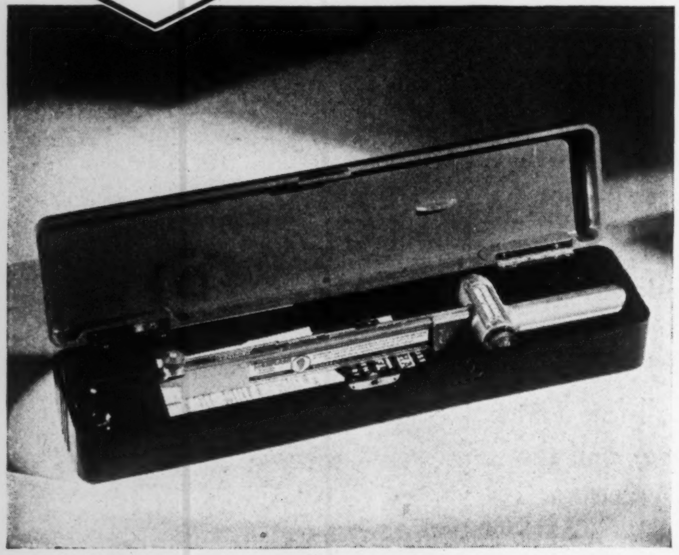
Practically every manufacturer can use parts of plastic to improve the saleability of his product. But it requires the proper plastic for your problem.

Send us your blueprints today for quotation.



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Call upon Eclipse for an UNBIASED recommendation.

Eclipse Designers, Engineers, Craftsmen are trained in moulding ALL PLASTICS. They know which of the many available modern plastic materials will most profitably serve your needs. Send blueprints or write for salesman to call.

serves the same capacity as compressed air cushions in other forms of pumps.

Fluid entering the suction chamber at the right passes to the working chamber through one-direction valve flaps shown on the inside dome. The pressure stroke or pulse forces the liquid through similar valves on the larger dome into the pressure or delivery chamber. Thus continuous flow is effected through the pump chambers.

Desired flow of fluid is controlled by a throttling valve. Restricted flow increases the pressure on the diaphragm causing the electromagnet to use a correspondingly lower amount of current. Complete throttling extends the diaphragm in the pressure chamber to its limit and then the working diaphragm. At this point, the armature core is at its lowermost position and the electromagnet will have the effect of a choke coil of high inductive resistance. The only current used then is the electrical loss. Therefore it is not necessary to disconnect the power supply when the throttle valve is closed for short periods of time. the exhaust valve closed.
phere.

Design of Disk Springs

(*Concluded from Page* 37)

.271 and $K = .696$. Then from Equations (11) and (12)

$$S = K\frac{P}{t_i^2} = \frac{.696 \times 90.000}{(.75)^2}$$
$$= 111{,}000 \textit{ pound per square inch}$$

$$\delta = C\frac{P\,r_o^2}{E\,t_i^3} = \frac{.271 \times 90{,}000 \times (9)^2}{30 \times 10^6 \times (.75)^3} = .157 \textit{ inch}$$

These values should be corrected because in the actual design the point of load application is ⅛ inch inside the edge as indicated in *Fig.* 13. Thus the distance $d = 2\frac{3}{4}$ inches and $r_o\text{-}r_i = 3$ inches. The corrected value of stress will be 110,000 X 2.75/3 = 101,000 pounds per square inch and the deflection at the points of application of the load will be .157 X $(2.75/3)^2 = .132$ inch.

Since these deflections are much smaller than half the thickness it may be expected that the load-deflection characteristic of this spring will be approximately linear, being modified only by friction along the edges. By supporting the spring at the neutral axis with a stepped edge, see *Fig.* 4, this friction may be greatly reduced.

By using the formulas and charts given in this paper, the design of Belleville springs to obtain specified nonlinear load-deflection characteristics becomes a relatively simple matter. Similarly, radially tapered disk springs may easily be calculated. The use of these types of springs has proved advantageous in many design applications.

"Help Yourself" BEARINGS
BUNTING
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STANDARDIZED BEARINGS
No. 39
● CAST BRONZE SLEEVE TYPE BEARINGS
● ELECTRIC MOTOR BEARINGS
● PRECISION BRONZE BARS
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THE BUNTING BRASS & BRONZE CO. TOLEDO OHIO U S A
LARGEST MANUFACTURERS OF CAST BRONZE BEARINGS IN THE WORLD

ALL you have to do whenever you want bearings is to help yourself from Bunting's big stocks. Completely machined and finished—ready for assembly—these "help yourself" bearings are available in hundreds of sizes for all mechanical applications and for electric motors of all makes from 1/50 hp to 100 hp. Write for catalog of these ready-to-use bearings, Bunting Precision Bronze Bars—machined I. D., O. D. and ends—and other Bunting products . . . The Bunting Brass & Bronze Company, Toledo, Ohio. Warehouses in All Principal Cities.

BUNTING Quality

BRONZE BUSHINGS • BEARINGS
PRECISION BRONZE BARS
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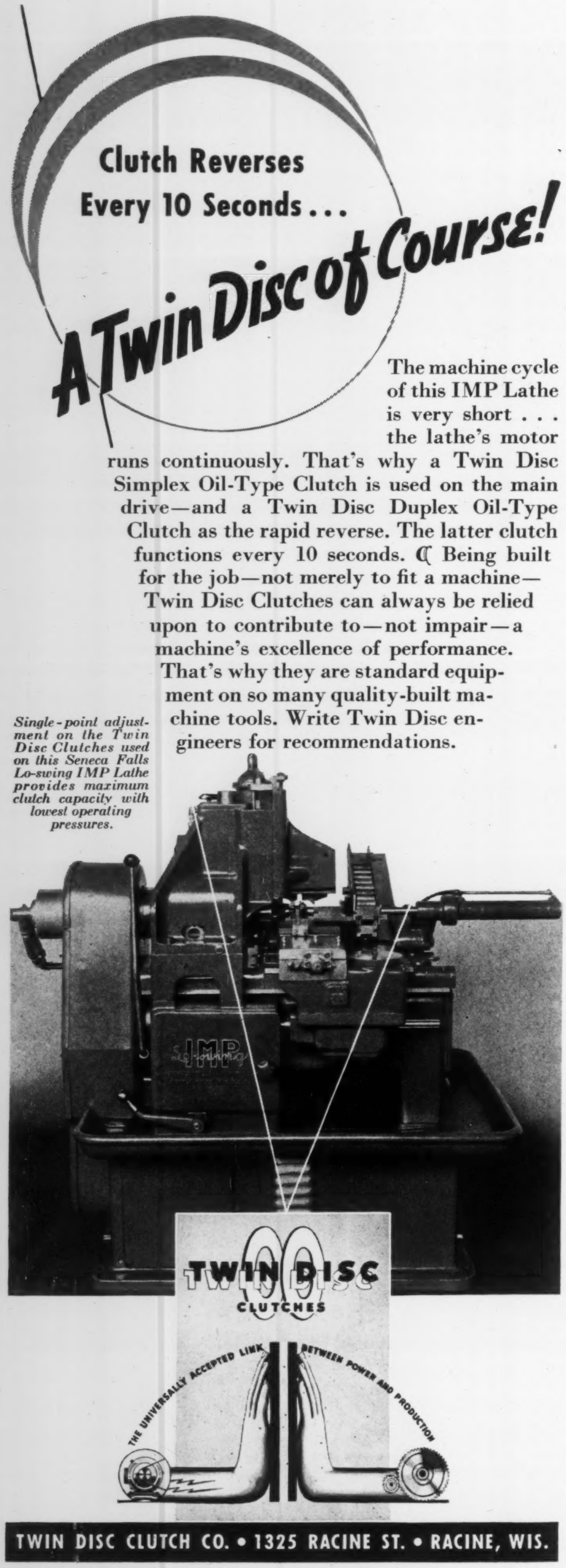


Clutch Reverses Every 10 Seconds . . .

A Twin Disc of Course!

The machine cycle of this IMP Lathe is very short . . . the lathe's motor runs continuously. That's why a Twin Disc Simplex Oil-Type Clutch is used on the main drive—and a Twin Disc Duplex Oil-Type Clutch as the rapid reverse. The latter clutch functions every 10 seconds. ℂ Being built for the job—not merely to fit a machine—Twin Disc Clutches can always be relied upon to contribute to—not impair—a machine's excellence of performance. That's why they are standard equipment on so many quality-built machine tools. Write Twin Disc engineers for recommendations.

Single-point adjustment on the Twin Disc Clutches used on this Seneca Falls Lo-swing IMP Lathe provides maximum clutch capacity with lowest operating pressures.

TWIN DISC CLUTCHES

THE UNIVERSALLY ACCEPTED LINK BETWEEN POWER AND PRODUCTION

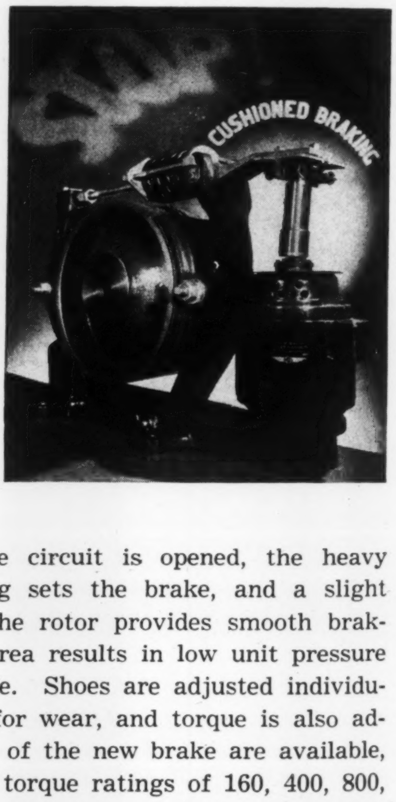
TWIN DISC CLUTCH CO. • 1325 RACINE ST. • RACINE, WIS.

NEW Materials and Parts

(For Engineering Department Equipment see Pages 75, 76)

Torque Motor Brake Announced

A NEW torque motor brake for alternating current service on elevators, cranes, hoists, and similar installations is announced by Cutler-Hammer Inc., 328 North Twelfth street, Milwaukee. This new brake is designed especially for those applications requiring positive, quick "cushioned" braking. A sturdy torque motor, operating through a simple, antifriction ball jack, releases the brake. The motor is stalled across the line when the brake is fully released. When the circuit is opened, the heavy helical torque spring sets the brake, and a slight flywheel action of the rotor provides smooth braking. Large lining area results in low unit pressure and longer lining life. Shoes are adjusted individually to compensate for wear, and torque is also adjustable. Five sizes of the new brake are available, providing maximum torque ratings of 160, 400, 800, 1600 and 3200 pound-feet on intermittent duty. Continuous duty ratings are slightly lower.



For alternating current service on elevators, cranes and hoists, torque motor brake provides positive, "cushioned" braking

Treatment Aids Zinc Finishing

MAAS & WALDSTEIN CO., 438 Riverside avenue, Newark, N. J., has developed a new method of treating the surfaces of zinc, zinc-coated and galvanized products before finishing them with lacquer, enamel, paint or varnish. The new treatment

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MANUFACTURER OF STANDARDS
CONTINUOUS BUSINESS FORMS
FORM FLOW REGISTER SYSTEMS
THE REGISTRATOR PLATEN
STANDARD'S CONTINUOUS FORMS
For handwritten or typed business forms

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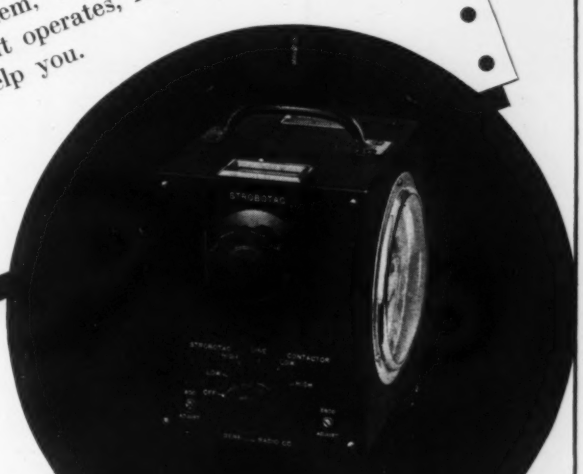
THE marginal punches on the continuous business forms manufactured for both machine and hand written records by The Standard Register Company have to be attractively and accurately printed. To inspect, for quality, the operations on their continuous carbon paper . . . while it is being punched, perforated and cut into strips as it goes through a special machine . . . ***Standard Register uses five General Radio STROBOTACS.***

Simple to operate . . . portable . . . light-weight . . . having a speed stopping capacity from 600 to 100,000 rpm . . . the new Type 631-B STROBOTAC can be equally as effective in your manufacturing processes as it has been for Standard Register and for hundreds of other manufacturers.

The STROBOTAC not only stops motion so that you can see movement in the most complicated machine frozen to a standstill, but it also permits viewing any machine in operation in exaggeratedly s-l-o-w motion . . . as slow as a fraction of an rpm.

If you have any problem, which requires seeing how your mechanical equipment operates, let us show you how the STROBOTAC can help you.

..."the Forms with the Punch"



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GENERAL RADIO CO., Cambridge, Mass.

High Efficiency Hydraulic Power

FOR

MODERN MACHINE TOOLS

Hydraulic power advantages are made more practical, easier to secure, through the new patented construction of Hannifin high pressure hydraulic cylinders. This exclusive construction is stronger, simpler, presents a better appearance, and is easily applied to a wide variety of uses. High efficiency hydraulic power is assured, with extra ruggedness to withstand severe service.

NO TIE RODS. This simpler design is stronger and eliminates a source of leakage. End caps may be removed without collapse of other parts of the assembly.

UNIVERSAL CAPS. Either end cap may be positioned independently, so that inlet port is at top, bottom, or either side. Either cap may be moved without disturbing the cylinder mounting or other parts.

AIR VENT PLUGS. Each end cap has air vents on three sides. With the inlet port at either side or bottom, there is always an air vent plug at the top.

LEAK-PROOF. Special mirror finish honing produces a cylinder bore that is straight, round, perfectly smooth, and concentric with the end caps. A perfect piston seal is obtained.

MANY TYPES AND SIZES. Available in six standard mounting types, with small diameter piston rod, 2 to 1 differential piston rod, or double end piston rod, in all sizes, for working pressures up to 1000 and 1500 lbs./sq. in. Furnished with or without cushion. Other types built to order, in any size, for any pressure.

Model CN
Model JN
Other Mountings Available

New Bulletin 35-MD gives complete specifications for all types.

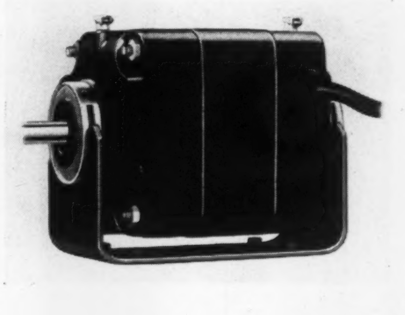
HANNIFIN MANUFACTURING COMPANY
621-631 South Kolmar Avenue, Chicago, Illinois
Engineers • Designers • Manufacturers
Pneumatic and Hydraulic Production Tool Equipment

HANNIFIN
HYDRAULIC CYLINDERS

eliminates the difficulty often encountered in coating zinc with organic finishes, unless the finish is selected with great care, when the oxidation products of zinc combine chemically with the constituents of many finishes and thus destroy them. Pre-treatment by M&W involves dipping zinc or zinc-coated products in a solution of a compound called Zinsol, which causes the formation of an alloy, zinc and another metal, on the surface. This alloy is chemically inert to moisture and organic finishes generally, so that it forms a stable foundation for any desired kind of finish.

Two Windings Possible on Small Motor

OHIO ELECTRIC MFG. CO., 5911 Maurice avenue, Cleveland, has announced a square fractional horsepower motor which may be wound for shaded-pole operation in sizes from 1/200 to 1/80-horsepower, and for permanent split capacitor operation in sizes from 1/150 to 1/20-horsepower at 3400 revolutions per minute; to 1/30-horsepower at 1700 revolutions per minute; to 1/50-horsepower at 850 revolutions per minute. Measuring 3¾-inch square by 4¾-inch long plus a ⅜-inch diameter shaft whose standard length is 1¼-inch, it can be supplied to mount in any desired position or with resilient base as illustrated. When wound for permanent split capacitor operation, the motor's efficiency is practically double that of the shaded pole motor. The small capacitor may be mounted separately or on the motor. Starting torque is slightly above full load and maximum running torque is about four times full load.



Fractional horsepower motor may be wound for shaded pole or permanent split capacitor operation in various sizes

Hydraulics Provide Accuracy

ACCURACY of control, to a minimum of 5 cubic inches per minute, is provided in a new, small variable volume hydraulic pump announced by the Denison Engineering Co., 236 North Water street, Columbus, O. Although originally designed to accommodate the lower pump capacities, the pump is said to be suitable for almost any job where slow, accurately controlled high pressure is required. A rapid traverse or quick take-up permits the pump to deliver its maximum volume when it is not work-

55
10
50
20
40
25
35

You can vary Hele-Shaw Fluid Power *Quicker* than a woman can change her mind

Hele-Shaw Fluid Power is oil under pressure. It provides instant and precise control. You can change its direction and vary its speed or pressure from zero to maximum, g-r-a-d-u-a-l-l-y or *instantly*—yes, quicker than a woman can change her mind.

This is *one* reason why so many machine designers, builders, and buyers are specifying Hele-Shaw Fluid Power for obtaining *controlled* linear or rotary motion. But there are other equally important advantages. Hele-Shaw Fluid Power offers wide flexibility of location. It increases production by instant and automatic adjustment to operating conditions. It sustains its pressures with a minimum loss of energy.

Write us for complete details. Ask us to show you how Hele-Shaw Fluid Power can be applied to advantage to the machinery you design, build or buy. Specify Hele-Shaw.

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OTHER A-E-CO PRODUCTS: Lo-Hed Hoists, Taylor Stoker Units, Marine Deck Auxiliaries.

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The positive piston-displacement Farval Valve, used to control the delivery of lubricant at each bearing, has but 2 moving parts and is extremely simple in operation.

• Since the production machines you build are your customers' first-line source of profit, any interruption to operation cuts directly into your earnings. One of the most frequent and costly of *all* interruptions—bearing troubles due to lack of lubrication—*can be avoided.*

Farval Centralized Systems of Lubrication *prevent* losses caused by faulty lubrication of bearings, by delivering the lubricant, in exact measured quantities, at proper intervals, to every bearing—missing none.

Furthermore, Farval *increases* earning capacity by reducing power consumption; eliminating labor of oiling by hand; saving lubricant; reducing repair bills; and by prolonging the life of machines.

Help your customers to maintain top production—install Farval and keep bearings fit. The Farval Corporation, 3265 East 80th Street, Cleveland, Ohio.

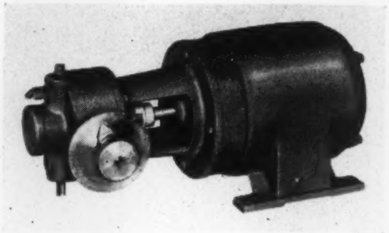
SPECIAL DELIVERY TO EVERY BEARING

Affiliate of The Cleveland Worm & Gear Company, Manufacturers of Automotive and Industrial Worm Gearing.

FARVAL

CENTRALIZED SYSTEMS OF LUBRICATION

ing against the load or against a light predetermined load. By means of an adjustment in the barrel the predetermined load can be established by setting the pressure at which the pump will stop delivering maximum volume and deliver the volume indicated on the control dial. This same control can be arranged to serve as an overload feature which will move the pump to no stroke, maintaining pressure but not delivering volume. The three-piston cylinder body and rotary valve are combined in a single shaft. Shaft and rotary are of heat treated tool steel, supported in one roller bearing and one ball bearing; the valve plate is of hydraulic bronze especially developed for the purpose. Two maximum volume capacities—100 cubic inches and 175 cubic inches—are offered in the same body size. This pump is said to be good for continuous operation at 1000 pounds per square inch and for intermittent operation at 2000 pounds per square inch.



Small variable volume hydraulic pump gives accuracy of control to a minimum of 5 cubic inches per minute

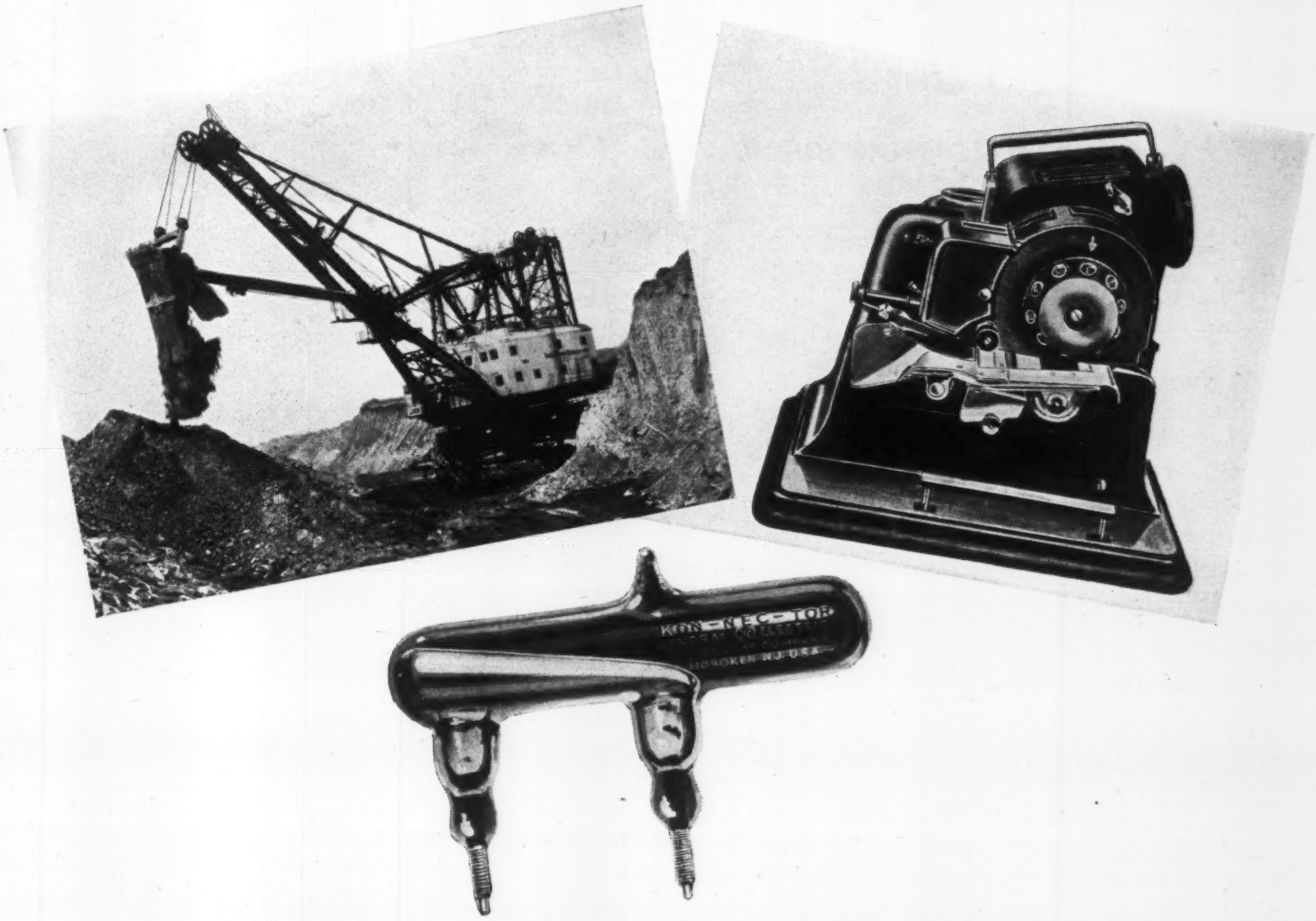
Formulate New Asbestos-Filled Plastic

TWO newly formulated, asbestos-filled Durez molding materials, known as Durez 38-443 and Durez 38-646, have been made commercially available by General Plastics Inc., North Tonawanda, N. Y. Durez 38-443 will withstand 490 degrees Fahr., has an impact strength of .23 and a compressive strength of 28,000. Specific gravity is 1.80. Durez 38-646 has an exceptionally low specific gravity for asbestos-filled molding compounds—1.59. Its heat resistance is 500 degrees Fahr., impact strength, .19, compressive strength 28,000. Its flexural strength, 9000, is high.

Light Relay Uses Photoelectric Cell

THE Light relay, or Light switch announced by Electronic Products Corp., 2667 East Grand boulevard, Detroit, has many uses where the frictionless interception of a beam of light is to close or open an electrical circuit to initiate desired actuation. Using a conventional missive type photoelectric cell, feeding one stage of amplification, the relay is very compact, measuring only 6 inches long, 4½ inches high, 3¼ inches wide. The amplifier is a standard radio tube whose output operates a telephone type relay, contacts of which are rated at 75 watts, ar-

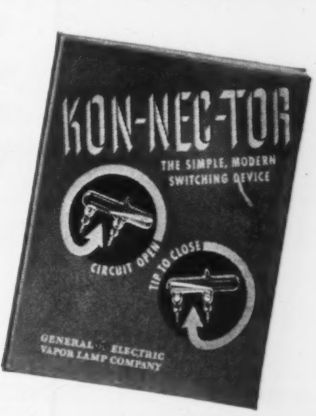
MOVING MOUNTAINS *or* METERING POSTAGE


KON-NEC-TOR
HOBOKEN N.J. U.S.A.

KON-NEC-TORS

Supply Unfailing Control

A mighty shovel for moving mountains and a high-speed machine for metering postage . . . they are alike in their demands on an electrical circuit with positive unfailing control. In machines of all kinds throughout industry KON-NEC-TOR Mercury Switches are still first choice. They are wear-proof and trouble-free, easily adapted to the design requirements of electrical equipment of all kinds. A clean make and break is always there. Corrosive fumes and moisture cannot harm these switches, ever. » » » Whatever your needs, there's a KON-NEC-TOR of the right type and capacity. Write for a copy of the KON-NEC-TOR Bulletin No. 603. It gives complete specifications and available engineering suggestions. General Electric Vapor Lamp Company, 825 Adams Street, Hoboken, New Jersey.


KON-NEC-TOR
THE SIMPLE, MODERN SWITCHING DEVICE
CIRCUIT OPEN
TIP TO CLOSE
GENERAL ELECTRIC
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GENERAL ELECTRIC
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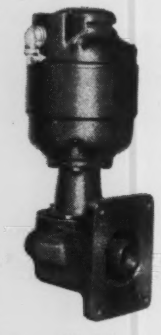
933K



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No. 11020A

THE
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PUMP

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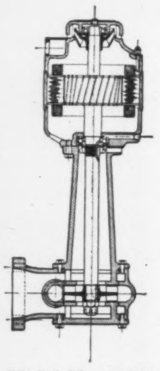
COOLANT PUMP

*NO UNSIGHTLY
EXTERNAL PIPING*

QUIET

A pump of increased efficiency that is easily mounted, hydrostatically balanced, self-cleaning and fully equipped with ball bearings. Split-second volume control. Designed to handle materials that contain grit and abrasives.



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Patents Pending

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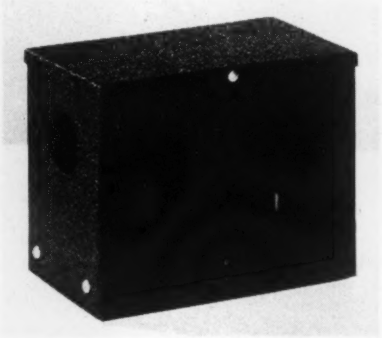
ranged for both a make and break circuit. A five-point terminal strip allows quick connection to the 115-volt, 50 or 60-cycle, or 110-volt direct current lighting line. The three other terminals are used for connection to the contacts of the magnetic switch. A potentiometer with a screwdriver slot provides for sensitivity adjustment so that various light levels may be used. The beam of light between the light source, housed in an identical container finished in black optical instrument enamel, and the photoelectric unit may extend up to 35 feet.



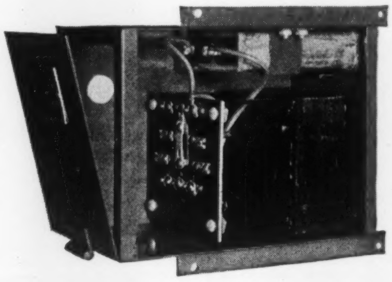
Conventional missive type photoelectric cell is used in the Light relay to close or open circuits

Motorpump for Compact Installations

FOR use in compact installations such as the base of machines where height is restricted, the No. 205 Centrifugal Motorpump has been announced by Brown & Sharpe Mfg. Co., Providence, R. I. Like the No. 212 described in *M.D.*, January, p. 62, it is suitable for supplying coolant for machine tools and light machinery where dirt or abrasives may be present in the liquid, and where a moderate volume of flow is desired at a low head. Hydraulically balanced, the impeller is designed to allow abrasives to be discharged without excessive wear within the housing. The discharge pipe clears the motor.

Varies Speed by Changing Voltage

A MULTI-STEP speed controller for alternating current motors, making possible the variation of motor speed by changing the input voltage, is shown in the illustration. Made by Raytheon Mfg. Co., 132 Willow street, Waltham, Mass., this



Speed controller for alternating current motors changes motor speed by varying input voltage

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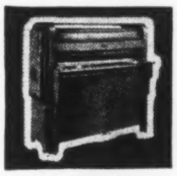
2 By turning out uniform . . . "Crystal Clear" . . . "Contrasty" . . . rugged . . . easily read prints on Pease *BLUEPRINT PAPER.*

3 By saving space . . . promoting convenience and efficiency of operation . . . harmonizing with any decorative scheme . . . with Pease-Hamilton *DRAFTING ROOM FURNITURE.*

4 By securing more penetrating illumination . . . sharper reproductions . . . cleaner separations . . . first-grade negatives and prints with Pease *PHOTOGRAPHIC ARC LAMPS.*

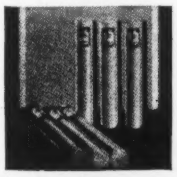
5 By getting practical suggestions based upon our 30 years of experience, engineering and research.

The Pease Planning Group . . . from Left to Right: H. J. Brunk, Chief Engineer; Thomas Lord, President; K. N. Nirison, Superintendent; W. E. Pashley, Vice President; A. F. Jacobs, Assistant Sales Manager.



Whether your requirements for equipment to make blueprints are extensive or limited, there is a Pease machine to produce quality prints at lowest square foot cost . . . large, rapid, continuous blueprinting machines down to small single operation units . . . a complete range of carbons, globes, lamps and other accessories. Compare your needs with our Blueprinting machinery catalog.

On blueprint papers, our program includes continual research, testing and inspection with respect to strength of stock . . . surface . . . color . . . and sensitizing formulae. Every hour we take samples of finished paper from our machines and make a complete printing, washing, developing and drying checkup.



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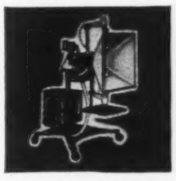

As for photographic arc lamps, we offer high speed, high quality, open flame Heli-O-Lite arc lamps in 7 individual types, as well as Super Actinic, high powered enclosed arc lamps in 5 individual types. Ask for our Photographic Arc Lamp literature.

And, finally, we hope you'll feel free to call us any time. Whenever we can put our 30 years experience . . . our engineering department . . . or our research department at your disposal, we shall be happy to do it.

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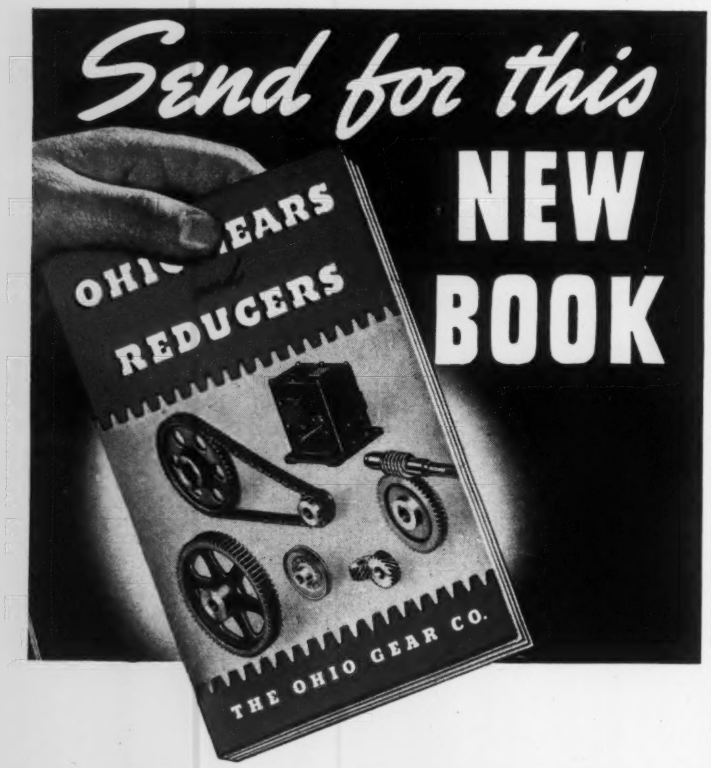

To Help you Select Gears
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Whether you design or maintain machinery you'll find this book helpful and informative. Complete, detailed information—on Stock and Special Gears, Speed Reducers, Pulleys, Chain and Sprocket and Power Transmission Equipment, engineering data and tables—right at your fingertips in this new 1939 Ohio Gear Book. And it's yours for the asking. Fill in Name and Company *and mail coupon today.*

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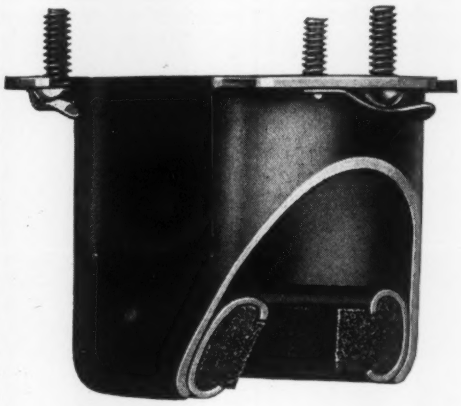
OHIO GEARS

method of speed controls permits operation of a motor thermostat or automatic switch because it insures that the motor will restart, regardless of the controller setting. Principal components, as can be seen, are an auto-transformer with voltage adjustment taps and an oil-filled condenser. There are no moving parts.

Guide Pin Covers with Felt Washers

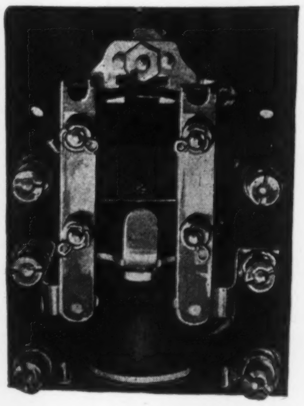
A NEW development in guide or leader pin covers has been announced by Wiesman Mfg. Co., Fourth and St. Clair streets, Dayton, O. Felt washers have been incorporated in new models, a feature particularly desirable for automatic presses where it is necessary to oil the guide pins about every 30 minutes. This guide pin cover with a felt washer, when filled with a heavy lubricating oil, will require filling only about once every 100 hours.



Felt washers have been incorporated in guide pin covers, a feature desirable when it is necessary keep oil on the pins

Small Reset Relays Announced

A NEW line of midget mechanical latch-in electrical reset relays has been placed on the market by Struthers Dunn Inc., Philadelphia. Made in both alternating current, 110 or 220 volts, 6 and 3 amperes respectively, and in direct current, 115 volts, 1 ampere, the new relays are provided with two coils. When the lower coil is energized the



Midget mechanical electrical reset relays have two coils, the lower latching the armature when energized, the upper releasing the latch

April . . .

• • • *Machine Design* will carry the Third Annual supplement on "Machine Drives and Controls". Full information on developments and new applications will be given. Concise yet complete presentation will bring engineering data files up-to-the-minute in usefulness.

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Vibration Absorption	Sealing Bearings
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Western's 37 years of experience in manufacturing and cutting felts is at your disposal. Extensive laboratory facilities insure the best possible solution to the above problems in your plant. You are under no obligation whatsoever in making use of our research services. Write today.

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WRITE FOR LITERATURE

armature picks up and latches in the energized position. Energizing the upper coil releases the latch allowing the armature to drop out. The relays are supplied with coils for either momentary or continuous duty, no power being required in the coil circuit to hold the armature in either position.

Vertical Speed Reducer Announced

A NEW vertical differential speed reducer, No. 40 VM, has been announced by Winfield H. Smith Inc., Springville, N. Y. It has a standard flange type motor rated at 1½-horsepower, 1725 revolutions per minute. Shaft of the motor is connected to the high speed shaft of the speed reducer by a flexible coupling. Heat treated alloy steel gears and shafts are used. Very compact, the reducer can be used with any make of motor.

A standard flange type motor rated at 1½-horsepower is used with vertical differential speed reducer

Motor-Pump Unit Developed

THE Motoair pump for vacuum or pressure offered by Motoair division of New Jersey Machine Corp., 1505 Willow avenue, Hoboken, N. J., requires no belts, gears, pulleys, sprockets or chains. It has an automatic visible oiling system, the supply of which can be seen at a glance in the cup reservoir. An integral unit, Motoair consists of a motor in various horsepowers, pump, oil condenser and oiling system. Except for special applications, standard stock motors are used. Absence of moving parts is said to mean longer life, less upkeep. Motoair can be installed in various positions without affecting lubrication or power.

Vernier Timers Need No Locking Device

VERNIER-SET timers, Series 2800, have been announced by Automatic Temperature Control Co., 34 East Logan street, Philadelphia. The time cycle, through use of the vernier principle, can be set accurately and maintained with no locking device. These timers are particularly suited for automatic machinery. Type 2803, of the series, has four arrangements of load circuits, the desired one being selected by simple adjustment of two slides, movable to left or right, and by the location of bridge connections. These load circuit changes can be made easily without tools and without dismounting the timer. Fine silver contacts carry 30 amperes at 110 volts alternating current. All types, including 2803, are equipped with the Telechron motor.

Magnet Wire Insulated with Resin

FORMEX wire, a new magnet wire announced by General Electric Co., Schenectady, N. Y., is insulated with a tough, flexible synthetic resin. Need for bulky protective coatings is eliminated in many instances, thus offering the designer opportunities to reduce the size of many products. Formex wire can be severely twisted and subjected to a temperature of 125 degrees Cent. for an hour without cracking.

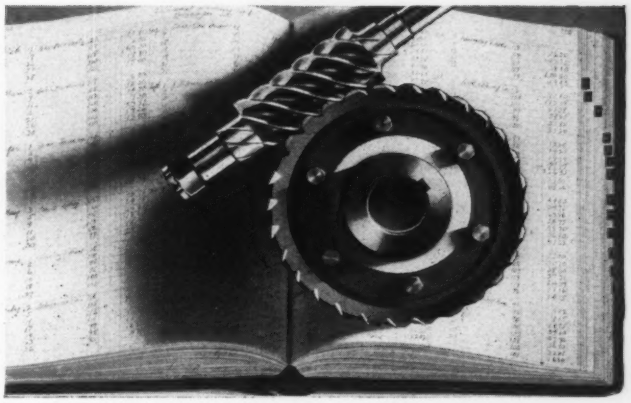
Strip Heaters Resist Corrosion

A NEW line of strip heaters for operation at sheath temperatures as high as 1200 degrees Fahr. has been announced by General Electric Co., Schenectady, N. Y. The new heaters are enclosed in porcelain-enamel steel casings so that they have the additional advantage of resisting rust and corrosion. Not only are these new heaters more attractive in appearance but their first cost is lower. In offering more resistance to rust and corrosion, it is expected that the porcelain-enameled units will substantially reduce replacement costs in heavy-duty applications.

Portable Blueprinter Put on Market

THE Elpro portable blueprinting machine has just been put on the market by Electronic Products Mfg. Corp., 208 West Washington street, Ann Arbor, Mich. Measuring 22 inches long, 16 inches high, 11 inches deep, with shipping weight of 33 pounds, it

Approximately 5000 *prints can be produced in the* 100-*hour life of the lamps in the Elpro portable blueprinting machine*



Clevelands Make Machines Pay Back Faster . . . Because

THEY OUTLIVE THE BOOKKEEPER

● Accurately-kept performance records *prove* that Cleveland Worm Gear Speed Reducers make machines pay back faster—by delivering power reliably, regardless of shock load, during every hour that machines operate.

In more than 20 major industries, equipment of many types driven by Cleveland Worm Gear Speed Reducers has continued in full operation through 12, 15 or even more years, with no need for repair or parts replacement on the Drive Units.

Have you a reference copy of the Cleveland Worm Gear Catalog in your files? Elaborate engineering data and clear, interesting illustrations provide valuable help in drawing worm gear drive specifications.

Cleveland District Representatives will gladly call for consultation with your own Engineers relative to the correct applications—whether standard or special—of Cleveland Worm Gear Drives to the machines you build. The Cleveland Worm & Gear Company, 3275 East 80th St., Cleveland, Ohio.

Affiliate: The Farval Corporation, Cleveland, Manufacturers of Centralized Systems of Lubrication

CLEVELAND WORM GEAR *Speed Reducers*

LOOKS GOOD — BUT CAN HE TAKE IT?

Pumps like boxers must be built to "take it." Durability and dependable performance have made Tuthill General Purpose Pumps champions of their class. Capacities from ½ to 50 g.p.m. Pressures up to 100 lbs. per sq. in. for Model C. pumps—up to 400 lbs. for Model CK (ball-bearing) pumps. Write for complete catalogs.

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operates on an ordinary power circuit—110-volt alternating or direct current. The light source consists of six special lamps with total wattage of 850. Approximately 5000 prints can be produced in the 100-hour life of the lamps. A highly polished aluminum reflector assures uniform light distribution over the field. In operation, the door shown in the illustration is opened and the printing paper is placed, yellow side up, on a substantial felt pad on the door's other side. The tracing is placed directly over the paper. When the door is closed, a light switch in the door frame is turned on for approximately 1½ minutes. Removed, the exposed print is placed in the developing cylinder, shown at left in illustration, for 2 or 3 minutes. The print is perfectly dry and ready for use when removed from the cylinder.

Pencil Cloth Gives Clear Prints

UNDER the name Pencil-tex, the Frederick Post Co., P. O. Box 803, Chicago, has introduced a pencil drafting cloth. The velvety surface gives the cloth unusual affinity for pencils of all degrees of hardness. Even the hardest of pencils is claimed to leave a sharp, uniform line, and blueprints made from these pencil tracings are clear and "non-fuzzy."

White Tape Protects Tracing Edges

EDGES of tracing and sketching paper are protected through use of the White Edger announced by David White Inc., 315 West Court street, Milwaukee. A special opaque white acetate fiber tape, ⅜-inch wide, designed for this edging machine by the Minnesota Mining & Mfg. Co., Milwaukee, has an exact amount of adhesive on it and makes a permanent edge which will not curl or peel off. Heat from a blueprint machine will not affect the tape and many edged sheets can be filed together without danger of sticking. The machine is simply clamped on the edge of a table or desk and can be operated by anyone. Sheets which have been edged may be run through a continuous blueprint machine as often as desired without danger of the tape's adhering to the glass.

Special white acetate fiber tape is put on the edges of tracing and sketching paper by edging machine

Meetings and Expositions

March 6-10—

American Society for Testing Materials. Regional meeting to be held at Deshler-Wallick hotel, Columbus, O. W. W. Heimberger, Buckeye Steel Castings Co., Columbus, is arrangements committee chairman.

March 7-10—

American Road Builders' association. Thirty-sixth annual convention and show to be held in Civic Auditorium, San Francisco. Charles M. Upham, 914 National Press building, Washington, is managing director.

March 8-9—

Air conditioning conference to be held at University of Illinois under sponsorship of department of mechanical engineering and the engineering experiment station of the College of Engineering.

March 8-10—

International Acetylene association. Thirty-ninth annual convention to be held at Rice hotel, Houston, Tex. Additional information may be obtained from the association, 30 East Forty-second street, New York city.

March 13-16—

American Society of Bakery Engineers. Annual meeting to be held at Edgewater Beach hotel, Chicago. Victor E. Marx, 1541 Birchwood avenue, Chicago, is secretary.

March 14-16—

American Railway Engineering association. Annual meeting to be held at Palmer House, Chicago. W. S. Lachery, 59 East Van Buren street, Chicago, is secretary.

March 14-18—

American Society of Tool Engineers. Annual meeting, and Machine and Tool Progress exhibition held at Convention Hall, Detroit. Ford R. Lamb, Room 428 Boulevard Temple building, 2567 West Grand boulevard, Detroit, is executive secretary.

March 16-17—

Society of Automotive Engineers. National aeronautic meeting to be held in Washington. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

March 28-30—

Society of Automotive Engineers. First national

McGILL MULTIROL Bearings

McGILL
MULTIROL
BEARINGS
in the Oil Industry

Exacting demands for maximum efficiency under the most severe operating conditions—that's the oil industry. The Brauer Machine and Supply Company, on location, in Oklahoma City, knows this—that is why their portable drilling rigs are equipped 100% with McGILL *MULTIROL* Bearings. For great load capacity in small radial space—nothing equals McGILL *MULTIROL* Bearings, especially under sustained heavy or intermittent shock loads.

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McGILL MANUFACTURING CO.
1450 N. Lafayette Street
VALPARAISO, INDIANA

"CULTURES"?

No! Copper springs $\frac{1}{16}$" long, slightly more than 50/1000" in diameter, with seven perfect coils. So tiny that, for photographing, they had to be attached to a glass with albumen!
In past years, "Peck Service" has produced thousands of sizes and kinds of springs—often doing the seemingly impossible. So, if you have a problem to be solved at reasonable cost, maybe we can help you. Write on your letter head for the

PECK CATALOG

—a handbook of springs and screw machine parts for designer, production manager and P. A.

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AND SCREW MACHINE PARTS

The Peck Spring Co. **10 Wells St.** **Plainville, Conn.**

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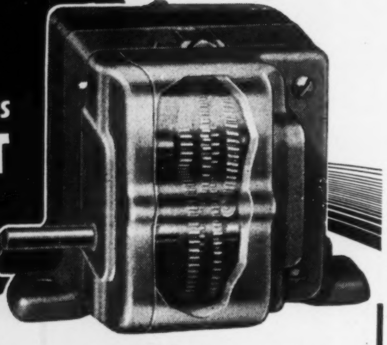
Worm Drive
Back Geared
FLEA POWER MOTORS
110 VOLT
AC, DC,
or Universal



Low Cost made possible by improved designs, large quantity production and production methods . . . Dependability developed thru hundreds of different applications in the field . . . Stamina built-in for continuous operation and . . . . . High torque developed thru integral back gearing . . . . Cased or skeleton types with standard gears that give "any" speed, that save engineering, cost, and space of requirements of auxiliary speed reducing means . . . . Single drives, double drives—from top, bottom, right or left. Miniature motors for a hundred uses; motors that make *automatic* tuning, *automatic* opening and closing, automatic features that make sales at incidental costs.

Sold singly, in dozens, thousands or millions.

SPEEDWAY MFG. CO.
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Cicero, Ill., U. S. A.

WRITE for SPECIFICATIONS and PRICES

passenger car meeting to be held at Hotel Statler, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

April 13-15—

Armour Institute of Technology, with the co-operation of Iowa State College, Purdue university, State University of Iowa, Universities of Illinois, Michigan and Wisconsin, as well as local and national engineering societies, will hold Midwest Power Conference at LaSalle Hotel, Chicago. L. E. Grinter, Armour Institute of Technology, Chicago, is conference director.

May 15-18—

American Foundrymen's association. Annual convention to be held in Cincinnati. Arthur J. Tuscany, Tuscany, Turner & Associates, Penton building, Cleveland, is executive secretary.

May 22-24—

American Gear Manufacturers' association. Annual meeting to be held at Cavalier hotel, Virginia Beach, Va. J. C. McQuiston, 602 Shields building, Wilkinsburg, Pa., is manager-secretary.

May 22-23—

American Society of Refrigerating Engineers. Annual meeting to be held at Hotel Hershey, Hershey, Pa. Additional information may be received from headquarters at 37 West 39th street, New York.

May 22-28—

World Automotive Engineering Congress. To be held in Hotel Pennsylvania, New York; at Indianapolis May 29-30; at Hotel Statler, Detroit, May 31-June 2; and at Hotel Fairmont, San Francisco, June 6-8. Further information may be obtained from the Society of Automotive Engineers, 29 West Thirty-ninth street, New York.

May 25—

American Iron & Steel institute. General meeting to be held at Hotel Waldorf-Astoria, New York. Walter S. Tower, 350 Fifth avenue, New York, is executive secretary.

June 19-22—

American Electro-Platers' society. International convention to be held at Asbury Park, N. J. W. J. R. Kennedy, 90 Maynard street, Springfield, Mass., is executive secretary.

MANUFACTURERS' *publications*

ALLOYS (NICKEL)—A new data sheet, "Iron-Nickel Alloys for Magnetic Purposes," section IV, No. 2 of the loose-leaf data book, "Nickel Alloy Steels," has been brought up to date by The International Nickel Co. Inc., New York. It describes these alloys for permanent magnets and also covers the high permeability alloys containing nickel.

BEARINGS (BRONZE) — Lubrite self-lubricating bearings and bushings, made of sand-cast bronze alloy, and related parts are described in bulletin No. 40 issued by Merriman Bros. Inc., 185 Amory street, Jamaica Plain, Boston. Types are illustrated and their features discussed. Second half of the book comprises engineering data aiding the choice of bearings and bushings.

BRAKES (MAGNETIC)—Bulletin No. 650 issued by Stearns Magnetic Mfg. Co., Milwaukee, describes the style DM magnetic disk brake.

CONTROLS (ELECTRICAL)—Schaefer Bros. Co., 1059 West Eleventh street, Chicago, has published a new catalog containing information on its control apparatus, rheostats and resistors. Descriptions are augmented by photographs, specifications and price lists.

CONVEYORS—Of interest to designers of machines incorporating conveying systems or continuous flow production, a new book, "Natural Laws Applied to Production," has been issued in its third printing by Mathews Conveyer Co., Ellwood City, Pa. It sets forth the role of continuous flow of materials in industry and includes action photographs of conveyers in operation.

FITTINGS—A booklet entitled "New and Better Fittings for Small Welded Lines" has been issued by Crane Co., 836 South Michigan avenue, Chicago, discussing the new forged steel socket welding fittings introduced by the company. For designers, useful tables are presented showing the hydrostatic bursting pressures, tensile pull tests and working pressures. There are numerous photographs and drawings.

GEARS—A simplified analysis of the problem of rating high speed double helical gears is given in a reprint of a paper by A. Peterson, who originated the method used for the past 20 years in calculating these gears manufactured by the De Laval Steam Turbine Co., Trenton, N. J.

INSTRUMENTS (THERMOMETERS)—Catalog No. 1170 issued by C. J. Tagliabue Mfg. Co., Park and

Jones
Cut and Molded Tooth Gears
W. A. JONES FOUNDRY & MACHINE COMPANY
CHICAGO
Herringbone
Spur
Worm
Rawhide and Bakelite Pinions
Mitre
Bevel

224 pages of VALUABLE INFORMATION on cut and molded tooth gears

Just off the press!

● Gear practice has changed with the times and the new 224 page Jones catalog covers the latest engineering and design information needed to apply herringbone, spur, worm, bevel and mitre gears, as well as rawhide and bakelite pinions, for almost every conceivable type of machinery application or drive problem.

If you use gears, or if you ever expect to use gears, you will want this unusually comprehensive treatise on gears for your reference library. The Jones organization will be pleased to send you a copy without any charges of any kind and without your incurring the slightest obligation.

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HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS
CUT AND MOLDED TOOTH GEARS — V-BELT SHEAVES
ANTI-FRICTION PILLOW BLOCKS — PULLEYS
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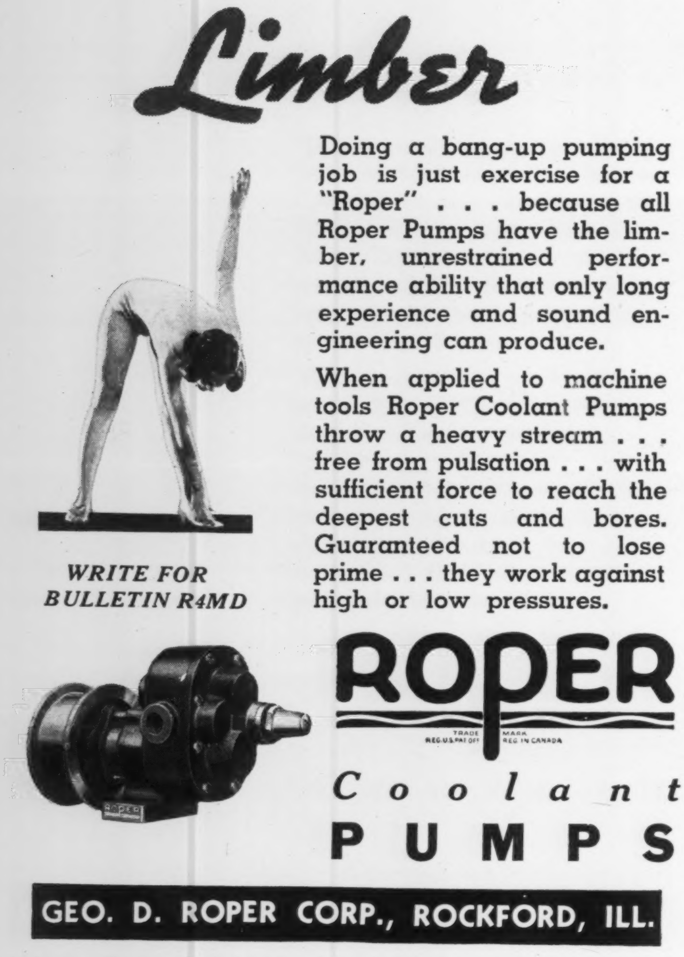

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Doing a bang-up pumping job is just exercise for a "Roper" . . . because all Roper Pumps have the limber, unrestrained performance ability that only long experience and sound engineering can produce.

When applied to machine tools Roper Coolant Pumps throw a heavy stream . . . free from pulsation . . . with sufficient force to reach the deepest cuts and bores. Guaranteed not to lose prime . . . they work against high or low pressures.

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Available from

MACHINE DESIGN
Penton Building, Cleveland, Ohio

Nostrand avenues, Brooklyn, N. Y., describes and illustrates dial-indicating thermometers of many types. Specifications are given along with pictures of typical installations.

LUBRICATION—The hand-operated lubricating system made by Bowen Products Corp., Auburn division, Auburn, N. Y., is described in catalog No. AF-74, just published. Photographs and detailed diagrams in color fully illustrate features of the system. New catalogs covering other types of the company's lubricating systems will be published soon.

MOTORS—Application data and price information on motors, generators, motor-generating sets, etc., is contained in the simplified motor price list and catalog No. 39 published by Diehl Mfg. Co., Elizabethport, N. J. The material is arranged for quick, easy reference. Color and illustrations add to the catalog's attractiveness.

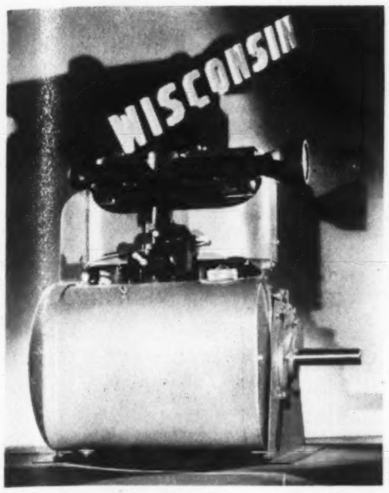
MOTORS—Harnischfeger Corp., 4400 West National avenue, Milwaukee, has published illustrated bulletin C-4 describing its P&H direct current mill motors. Center of the folder is a two-page spread in color showing a cutaway view of the motor with design features clearly pointed out.

MOTORS—Lima Armature Works Inc., 438 North Main street, Lima, O., has published an illustrated bulletin in color covering its gear-shift motor for use with many types of machines requiring variable speeds.

MOTORS, CONTROLS AND DRIVES—Westinghouse Electric & Mfg. Co., East Pittsburgh, has issued the following new catalogs and leaflets discussing its products: Booklet B-2159, on geared drives for all types of industries; descriptive data 3610, on gearmotors of several reductions and horsepower ratings; booklet B-2164, on synchronous motors, including information on applications and typical torque requirements; descriptive data 3620, on types SH and DH speed reducers; instruction leaflet 2806, discussing the use and care of the type L-33 electrical interlock for alternating current; and booklet B-2131, describing combination linestarters consisting of the "De-ion" linestarter and circuit breaker.

SPEED REDUCERS—Three styles and 11 types of motorless speed reducers ranging in sizes from 1/20 to 7½-horsepower, are described in illustrated bulletin 22-33 published by Janette Mfg. Co., 556 West Monroe street, Chicago. Complete construction features, specifications, order instructions and prices are listed. Information on mounting and dismounting positions add to the book's value.

SPEED REDUCERS—Allis-Chalmers Mfg. Co., Milwaukee, has issued a new leaflet 2203-B on its compact self-contained gearmotor speed reducers for efficient low speed operation. This leaflet presents numerous line drawings and installation photographs showing typical gearmotor applications, and includes a table of ratings and speeds with 1750 revolutions per minute motors.



A reproduction of Model AC4 — 8 to 16 H. P. engine with side mounted gas tank.

A complete line 1 to 30 H. P.

SAFE — DEPENDABLE POWER FOR ANY JOB — ANY CLIMATE

Wisconsin Heavy-Duty Air-cooled Engines require no "Fussing-with" or special attention. They take care of themselves.

HEAVY DUTY AIR COOLED ENGINES by WISCONSIN MOTOR CORPORATION

WISCONSIN
MOTOR CORP., MILWAUKEE, WIS.

Long Profit GEARS

INTERNAL GEARS
WORMS
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For Precision Instruments, Machine Tools and Larger Machinery

There's one way to get extra gear service in your machines—and that's to use Abart cut gears. Not only do Abart gears have longer life but they minimize replacements and give a longer profit by less maintenance of your machines. No stocks—made only to your specifications or B/P. Send us *your* specifications for estimate.
SPEED REDUCERS Many types and sizes in stock for immediate shipment. Write for catalog today.

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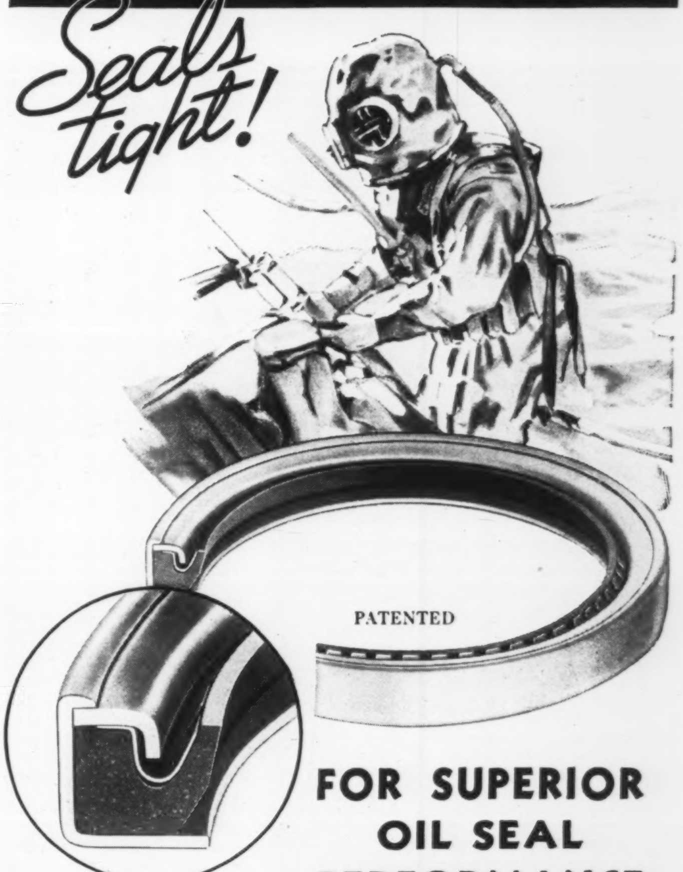

FOR SUPERIOR OIL SEAL PERFORMANCE

As a diver's helmet keeps water out and air in, for the protection of the diver—the Garlock KLOZURE keeps dust, dirt and water out and keeps oil and grease in, for the protection of bearings of all kinds. The exclusive KLOZURE sealing ring resists oil and heat, even at high temperatures; it does not become soft and flabby; gives superior oil seal performance. Write for catalog!

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Palmyra, N.Y.
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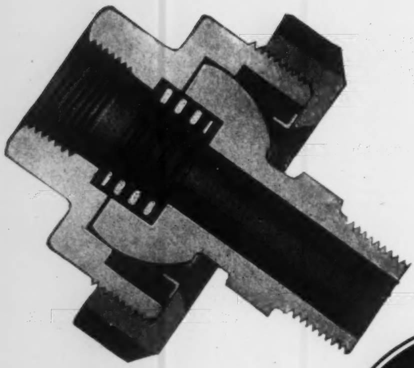
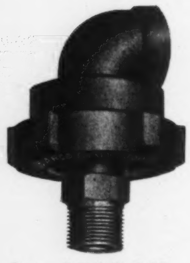
SPLIT-KLOZURE

To meet the need for an Oil Seal that can be installed around the shaft rather than over the end of the shaft, Garlock has developed the new patented SPLIT-KLOZURE. For all shafts of 3" diameter and larger.

TRADE GARLOCK MARK

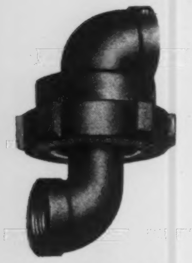
GARLOCK



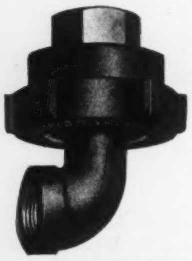


Swivel 7AS-8CS.

BARCO SWIVEL JOINTS



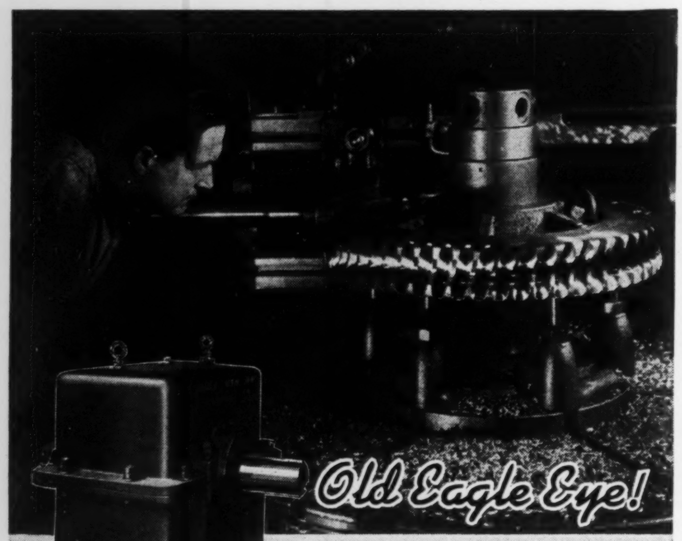
Swivel 7AS-8BS.



● Don't take chances on expensive shutdowns and production delays. Where pipe movement is involved, depend on BARCO joints to solve your problem.

BARCO MANUFACTURING COMPANY
1813 Winnemac Ave., Chicago, Ill.

Swivel 7S-8BS



D.O. James men have the training and knowledge to give an *Eagle Eye* supervision. This experience—and modern equipment—assures you worm gears and worm gear reducers that are most accurate—*and will do the job!*

Send for Catalog No. 150—180 Pages of Engineering Data, Weights and Prices on all Types and Kinds of Speed Reducers

D.O. JAMES MANUFACTURING CO.
1120 W. MONROE STREET • *ESTABLISHED 1888* • CHICAGO
MAKERS OF ALL TYPES OF GEARS AND GEAR REDUCERS

Business and Sales Briefs

APPOINTMENT of James L. Cawthon Jr. as development engineer has been announced by Malleable Founders' Society. The appointment is occasioned by a new activity of the society involving the furnishing of technical data to users of malleable castings, engineering of new uses for the material and other services to users of malleable castings.

◆

Revere Copper & Brass Inc. has appointed Keith C. Bowers, formerly of the company's St. Louis office, as sales representative in Western Missouri and Kansas, with headquarters at 325 Ward Parkway, Kansas City, Mo.

◆

M. H. Jewett, with headquarters at Room 301, Union building, 1836 Euclid avenue, Cleveland, has been appointed district representative for the Northern Ohio territory by the American Flexible Coupling Co., Erie, Pa.

◆

A tract to house a new building for the company's Chicago headquarters has been purchased by General Electric Co. Work will soon be started on the building which will provide space for the company's sales offices, warehouse and service shop.

◆

R. F. Jackson has been made manager of mechanical sales of the Baltimore branch office of the mechanical goods division of U. S. Rubber Co. Heretofore this office was under supervision of the Philadelphia branch, but now will operate independently.

◆

Since 1916 Pittsburgh district manager of Electric Controller & Mfg. Co., Cleveland, A. C. Dyer has been made general sales manager, with headquarters in Cleveland.

◆

Electro-Alloys Co., Elyria, O., has appointed John R. Heckman as midwestern representative, with headquarters at 122 South Michigan avenue, Chicago.

◆

Robert B. Ellison has been made president of the Ellison Bronze Co., Jamestown, N. Y. C. F. Oliver Ellison was appointed secretary and A. C. Nordstrom, vice president and treasurer.

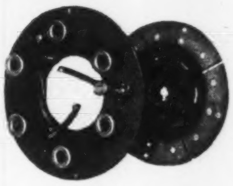
◆

Announcement has been made of the appointment of the Industrial Sales & Engineering Co., 3118 North

"Proved Very Satisfactory"

ROCKFORD

Spring-Loaded Clutch Suits ARIENS-TILLER



"Rockford Clutches have proved very satisfactory in Ariens-Tillers. They give us the smooth engagement and load carrying capacity required in our unit and we are entirely satisfied in having selected this clutch for our machine." The Model A tillage combine, pictured, uses an 8½" Rockford Spring-Loaded Clutch in the main drive for its generally ideal characteristics and especially the close-coupled feature. Rockford Clutches are made in 6" to 20" sizes, 2 to 80 h.p. at 100 r.p.m., single or double drive plates, oil or dry operation. Write today for information.

PULLMORE CLUTCHES
Made in single and double types; Pullmore Clutches are unexcelled for applications requiring a compact, powerful multiple disc clutch.

ROCKFORD DRILLING MACHINE DIVISION
Borg-Warner Corporation, 304 Catherine Street, Rockford, Illinois

---

LEIMAN BROS. NEW

SURFACE GRINDER DUST COLLECTOR

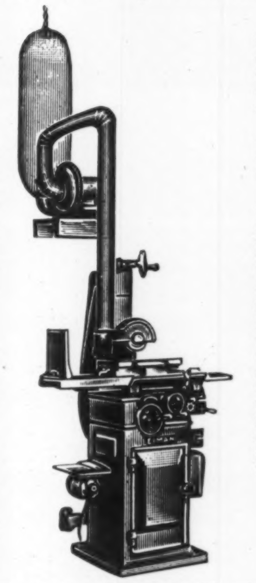
For Your Grinder of Whatever Make

A Complete Motor-Driven Unit at Small Cost

This small, yet powerful, machine occupies but 11" x 13" space. It consists of a sturdy, powerful suction blower, electrically driven, with piping connections to the surface grinder and to the high grade dust disposal bag.

It can easily be placed on the floor or a shelf on a nearby pillar or wall, out of the way. It can be plugged into any lamp socket.

The strong suction of air draws away all the light metallic and light abrasive dust created when grinding. This highly irritating dust is caught in a bag made of specially treated filter cloth which may be quickly emptied when necessary.



Don't Breathe Grinding Dust!

"The direct cause of silicosis is the inhalation of minute particles of silica dust. While the type of pulmonary lesion depends on the particular dust inhaled, the underlying pathological principle is the same in all forms of the disease, viz., an ultimate fibrosis and replacement of the elastic lung tissue by a hard unyielding fibrous tissue."

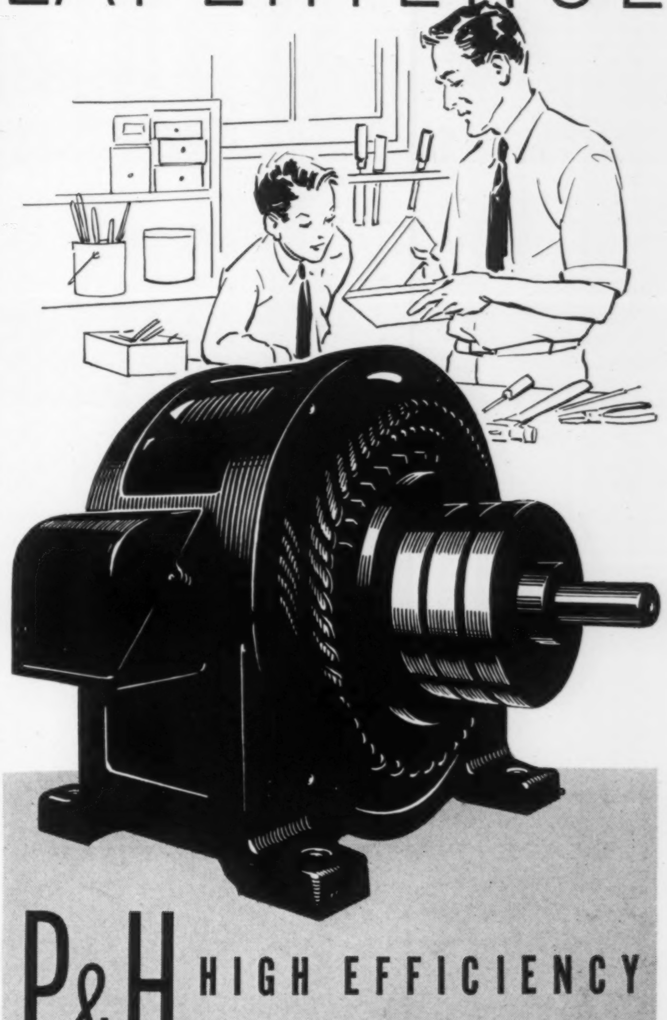
SILICOSIS IS INCURABLE!

GET FREE INFORMATION AND FOLDER ABOUT THE DANGERS OF DUST

LEIMAN BROS., Inc., SG23-P WALKER ST.
NEW YORK CITY

MAKERS OF GOOD MACHINERY FOR 50 YEARS

EXPERIENCE



P&H HIGH EFFICIENCY ELECTRIC MOTORS

Through more than fifty years, this organization has practiced true craftsmanship in building electric motors for many special purposes. Unhurried production, faithful attention to detail and the use of only the best materials are responsible for the outstanding manner in which P&H electric motors meet the most severe demands for service. If you use motors it will pay you to investigate. Address the Harnischfeger Corporation, 4556 West National Avenue, Milwaukee, Wisconsin.

Convertible Slip-Ring and Squirrel-Cage Motors up to 125 h.p. capacities. Literature on request.

HARNISCHFEGER CORPORATION
MOTORS • HOISTS • WELDING ELECTRODES P&H ARC WELDERS • EXCAVATORS • ELECTRIC CRANES

Broad street, Philadelphia, as district sales representative for the Southeastern Pennsylvania, New Jersey and Eastern Maryland territory of American Flexible Coupling Co., Erie, Pa.

◆

Re-election of Robert W. Wolcott as president of Lukens Steel Co., Coatesville, Pa., was recently announced. Other officers re-elected are: Charles L. Huston, first vice president; F. H. Gordon, vice president in charge of sales; and D. S. Wolcott, vice president.

◆

F. E. Blackburn has become associated with the Ohio Ferro-Alloys Corp., Canton, O. sales department as sales engineer.

◆

Laminated Shim Co. Inc., Long Island City, N. Y., celebrated its twenty-fifth anniversary some weeks ago.

◆

Recent elections of H. G. Alexander as board chairman and Herbert P. Ladds as president and director have been announced by the National Screw & Mfg. Co., Cleveland. Mr. Alexander is resigning as president of Sweet's Steel Co., Williamsport, Pa.

◆

Several changes in personnel have recently been announced by Plaskon Co., Toledo, O. These are: Richard B. Harrison, vice president, has been placed in charge of the Toledo sales office, and Whiting N. Shepard, formerly in charge of the Toledo sales office, has been made head of the sales and service in the Chicago area, assisted by G. T. Walker Jr. Carleton Ellis Jr., until now in charge of the Chicago office, has been transferred to Toledo.

◆

E. Clay Howell has been appointed as vice president and general manager of Haven Malleable Castings Co., Cincinnati.

◆

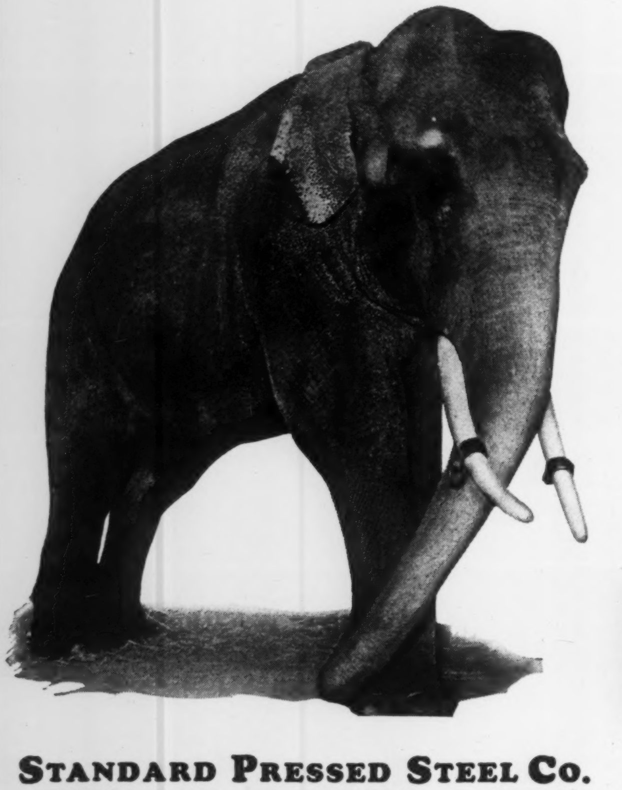
Previously general sales manager, E. E. LeVan has been elected vice president of Haynes Stellite Co., and is located at the company's general office and works at Kokomo, Ind.

◆

Identified for more than twenty years with the chain industry, D. Robert Coutts has become associated with International Chain & Mfg. Co., York, Pa. His new position is that of western sales manager and he will be located at 2109 South Wabash avenue, Chicago.

◆

Another announcement by the Plaskon Co. is that a new office in Rochester, N. Y., at 1045 Lincoln-Alliance Bank building, has been opened, in charge of C. Burton Wing who will handle sales and service in that territory. A. E. Egerter has moved to Toledo, into the sales and advertising department of the company. H. W. DeVore with headquarters in Toledo, will supervise sales and service for Ohio and Michigan.



They used to say
"STRONG AS AN ELEPHANT"
. . . *but now they say,*
"IT'S STRONG AS
UNBRAKO
SOCKET SCREWS"

Because strength is a primary requisite in socket screws, we have steadily adapted the stronger, tougher alloys to our needs and have at the same time developed more improved methods of heat treating. All this assures "Unbrako" Products being tops in tensile strength and hardness. You just can't do better than specify "Unbrako" all the time. Send for Samples, Prices and Details.

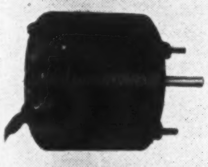
Fig. 232
"Unbrako"
Hollow Set
Screw.

Pats. Pend.
Fig. 1434
Knurled "Unbrako" Socket Head Cap Screw

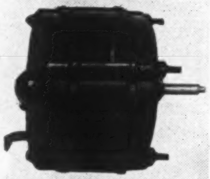
STANDARD PRESSED STEEL CO.
JENKINTOWN, PENNA.
BOX 102
BRANCHES
BOSTON
DETROIT
INDIANAPOLIS
BRANCHES
CHICAGO
ST. LOUIS
SAN FRANCISCO

VICTOR
Super-Power
MOTORS

MODEL M41



MODEL M35



MODEL M6

SHADED POLE . . .
. . . Induction Type

Victor offers an outstanding line of quality-built motors of fractional power ranging from 1/200 to 1/10 H. P. Ideal for such applications as fans, blowers, animated displays, timing devices, etc. Years of successful motor building — equipped to solve difficult engineering problems. Write for literature today!

Manufacturers' Representatives:
A few territories not yet assigned.
If interested, write us at once.

VICTOR ELECTRIC PRODUCTS, INC.
845 Reading Road **Cincinnati, Ohio**

VERTICAL MOUNTING
- - as well as
HORIZONTAL

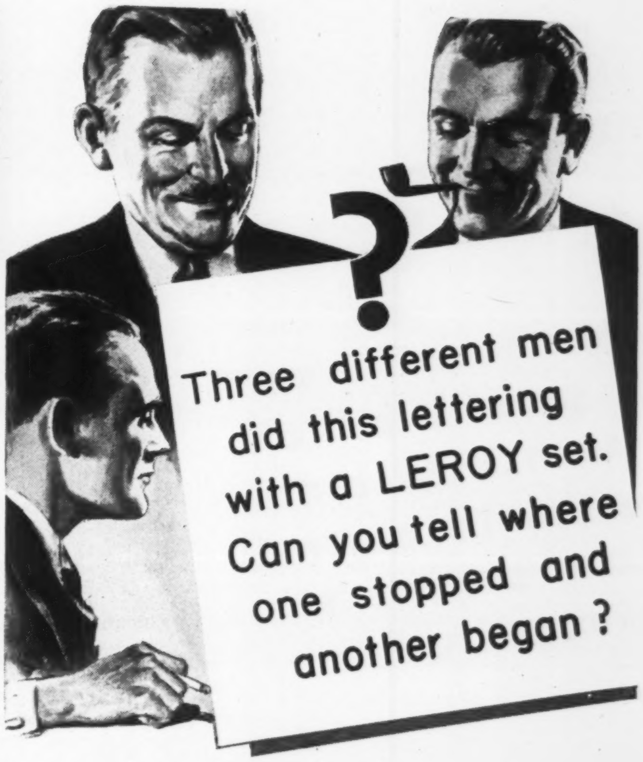
in the 3 sizes of
Rotary Geared
MOTORPUMPS
Nos. 101, 102 and 103

— Specify Motorpumps for Flexibility and Economy. Write —

Brown & Sharpe Mfg. Co.
Providence, R. I., U. S. A.

BROWN & SHARPE PUMPS

BS


?
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Here is a lettering technique which produces accurate, *uniform* lettering—with speed and ease. No guide lines, no preliminary roughing in. Complete, finished letters are formed in one operation.

A Leroy set consists of patented templates, a simple scriber and foolproof, tubular pens. Each template produces both vertical and slanting letters and numerals. The work is performed well above the template, in full view of the operator; there is no danger of smearing when the template is removed.

There are templates and pens of all sizes—sold singly or in sets. You make your selection to fit your own standards and requirements. Prices are moderate.

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NEW MACHINES–
And the Companies Behind Them

(For illustrations of other outstanding machinery see Pages 46-47)

Agricultural

"Clipper" combine, Massey-Harris Co., Racine, Wis.
Tractor and plow, Minneapolis-Moline Power Implement Co., Minneapolis.

Air Conditioning

"Packaged" air conditioners, York Ice Machinery Corp., York, Pa.
Room air circulator, Ad-Lee Co., Chicago.

Bakery

Automatic slicer, Micro-Westco Inc., Bettendorf, Ia.
Progressive or staggered bread slicer, Bakery Machinery Corp., Milwaukee.

Canning

Tomato scalder, A. K. Robins & Co. Inc., Baltimore.
Corn trimmer, The Sinclair-Scott Co., Baltimore, Md.
Jar closing machine, E. W. Bliss Co., Brooklyn, N. Y.

Confectionery

Ice cream batch mixer, Cherry Burrell Corp., Chicago.
Refrigerated cabinets, Kold-Hold Mfg. Co., Lansing, Mich.

Construction

Packer-head pipe machine, Concrete Pipe Machine Co., Sioux City, Pa.
Block press, Kent Machine Co., Cuyahoga Falls, O.
Vibrator-stripper, Multiplex Concrete Machinery Co., Elmore, O.
Portable bulk-cement plant, Heltzel Steel Form & Iron Co., Warren, O.
Traction-driven road sweeper, Frank G. Hough Co., Chicago.
Sand spreader, Hercules Motor Corp., Canton, O.
Compressor, Schramm Inc., West Chester, Pa.
Mixers, Ransom Concrete Machinery Co., Dunellen, N. J.
Heavy-duty combination grinder and crusher, Prater Pulverizer Co., Chicago.
Concrete mixers, Chain Belt Co., Milwaukee.

Dairy

Cottage cheese filling machine, Filler Machine Co., Philadelphia.
Automatic rotary filler and capper, Specialty Brass Co., Kenosha, Wis.
Cabinet cooler, Cherry Burrell Corp., Chicago.
Cold raw milk filter, Stamsvik Co., Pittsburgh.

Domestic

Refrigerator, Gale Products, Galesburg, Ill.
Automatic electric roaster, Miracle Products Inc., Chicago.

Finishing

Automatic polishing and buffing machine, Packer Machine Co., Meriden, Conn.
Semiautomatic spray coating machine, Eclipse Air Brush Co. Inc., Newark, N. J.

Metalworking

Marking machine, Geo. T. Schmidt Inc., Chicago.
Cable armoring machine, Sleeper & Hartley Inc., Worcester, Mass.
Contour grinder, Stanley Electric Tool Div., New Britain, Conn.
Hydraulic press, Southwark Div., Baldwin-Southwark Corp., Eddystone, Pa.
Milling machine, Brown & Sharpe Mfg. Co., Providence, R. I.
Feeding and straightening unit, F. J. Littel Machine Co., Chicago.
High-speed, precision, tool-room lathe, Hardinge Bros. Inc., Elmira, N. Y.
Unit head type drilling machine, G. A. Gray Co., Cincinnati.
Sheet metal former, Engineering and Research Corp., Riverdale, Md.
Cut-to-length shear, Cleveland Punch & Shear Works Co., Cleveland.
High-speed press, V & O Press Co. Inc., Hudson, N. Y.
All-purpose die-cutting band saw, Continental Machines, Inc., Minneapolis.
Heavy-duty, bench-type grinder, Diehl Mfg. Co., Elizabethport, N. J.
Disk grinders, Gaston Power Tool, Evergreen Park, Ill.

Printing

Heavy-duty autoshaver, Wood Newspaper Machinery Corp., Plainfield, N. J.
Continuous suction stream feeder, Christiansen Machine Co., Racine, Wis.
Glider, Hammond Machinery Builders Inc., Kalamazoo, Mich.
Miterer, Craftsman Machinery Co., Boston.
Driller-slotter, Challenge Machinery Co., Grand Haven, Mich.
Printer-slotter, F. X. Hooper Co. Inc., Glenarm, Md.
Saw trimmer, Milwaukee Saw Trimmer Corp., Milwaukee.
Electric proofpress, Vandercook & Sons, Chicago.

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The correct oil film to each individual bearing... automatically
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LONG ISLAND CITY NEW YORK

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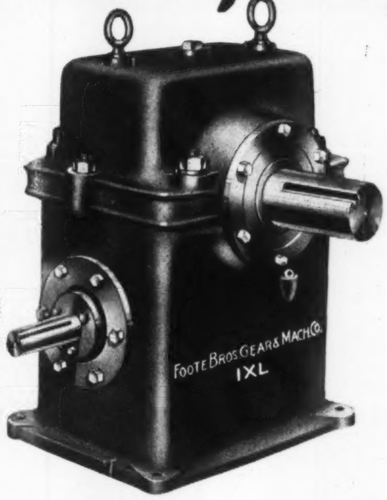

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WANTED: Mechanical designer, experience on heavy paper box machinery preferred. State experience, training and general qualifications, also salary expected. Eastern location. Address Box 114, MACHINE DESIGN, Penton Building, Cleveland, Ohio.

WANTED: Mechanical engineer with ability to develop and qualify as assistant chief engineer. Age 35 to 45, with design experience in connection with relatively heavy equipment comparable to paper working machinery. Shop experience or contact that provides background and familiarity with shop practice in connection with design, is very important. Opportunity for permanent career with long established company manufacturing widely known line of machinery. Reply giving full details of education and experience to Box 115, MACHINE DESIGN, Penton Building, Cleveland, Ohio.

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Positions Available—20c a word, with a minimum charge of $10.00, which permits the use of fifty words.

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GASOLINE MOTORS

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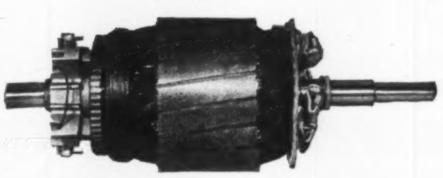
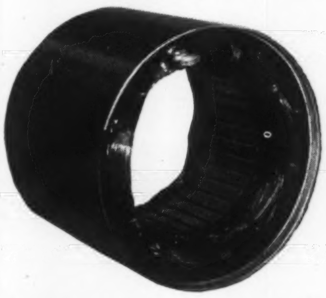
✓ CHECK THESE FEATURES *of* Wagner Motors

Rotor



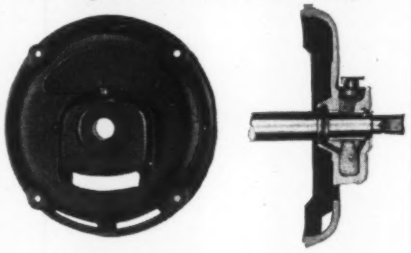
✓ All Wagner rotors are dynamically balanced to insure freedom from vibration. Rotor slots are skewed and combined with careful electrical design to insure a motor with a minimum of magnetic noise. Rotor shaft is designed to carry mechanical overloads without perceptible deflection.

Stator



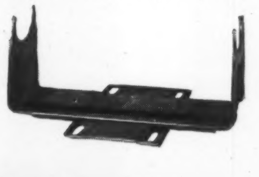
✓ Wagner stators are known for their strength and rigidity, in addition to their mechanical simplicity. Stator coils are well insulated and securely wedged in place. Stator core and windings are thoroughly impregnated with heavy insulating varnish and carefully baked in drying ovens to drive out all moisture. Frame is of rolled steel—strong, rigid, will not get out of alignment.

Endplates and Bearings



✓ Concentrically machined endplates and diamond-bored bearings—insure true alignment of bearings, perfect centering of shaft, and uniform airgap. Oil wells are roomy—hold large quantity of oil-soaked wool yarn which carries an uninterrupted supply of filtered oil to all bearing surfaces.

Base Construction



✓ Wagner fractional-horsepower motors can be equipped with either rigid-mounted base, resilient-mounted base, or flanged or machined endplate mounting. Bases are formed from steel plate and are of electric-welded construction. Mounting slots are so spaced as to permit interchangeability of motors of the same frame size.

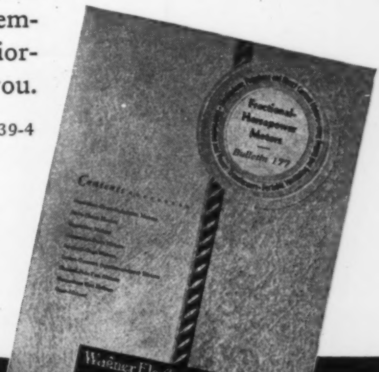
There are many other details about Wagner fractional-horsepower motors that should be of interest to engineers and manufacturers of motor-driven machinery and appliances. Wagner welcomes an opportunity to demonstrate their features of superiority that will prove useful to you.

M39-4

ASK for this

Bulletin No. 177 on

Wagner Fractional-Horsepower Motors



Fractional-Horsepower Motors

Bulletin 177

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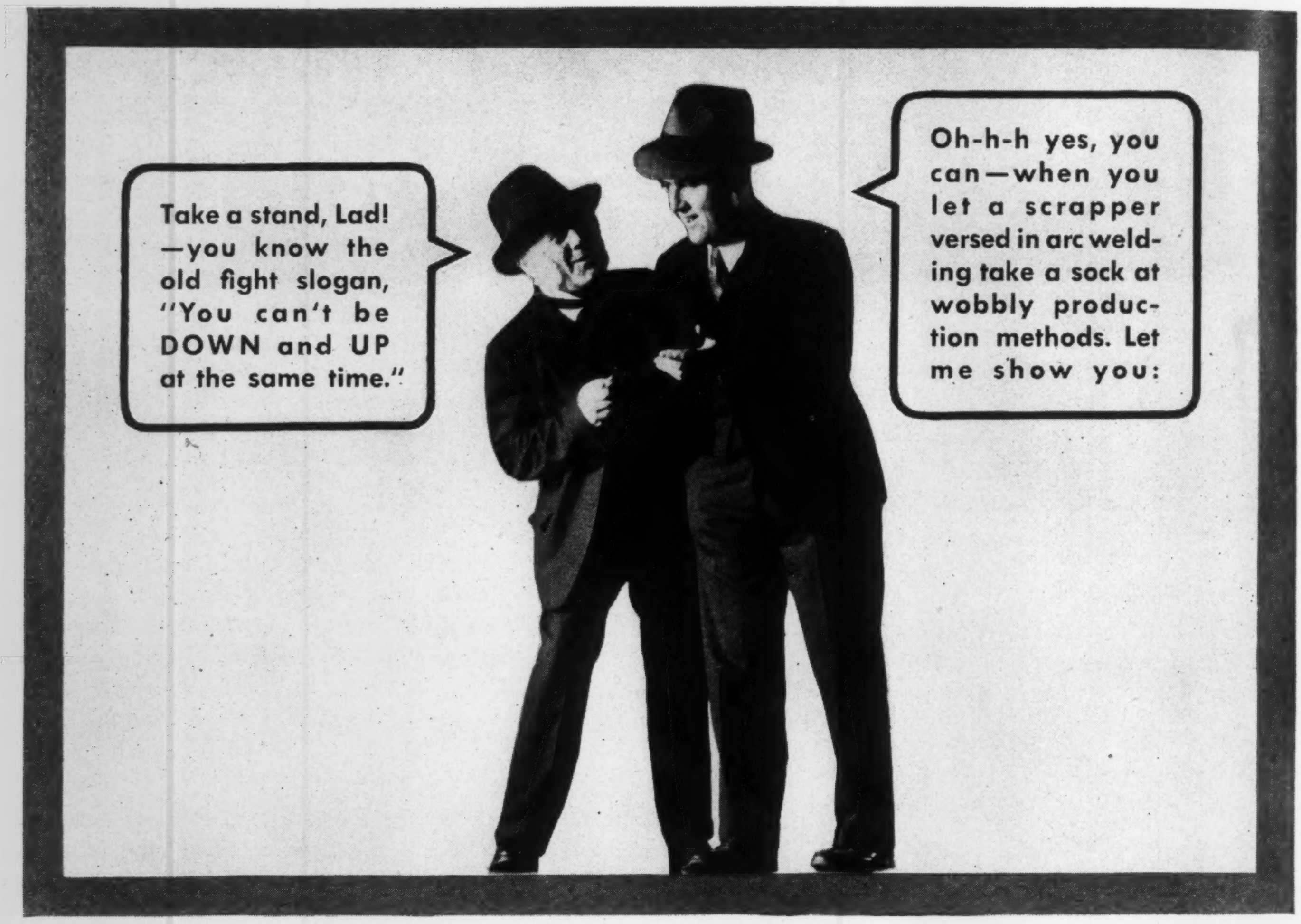
Wagner Electric Corporation

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, U.S.A.

FANS . . . . MOTORS . . . . TRANSFORMERS . . . . BRAKES


Take a stand, Lad! —you know the old fight slogan, "You can't be DOWN and UP at the same time."
Oh-h-h yes, you can—when you let a scrapper versed in arc welding take a sock at wobbly production methods. Let me show you:

HOW TO DRIVE COSTS DOWN AND QUALITY UP

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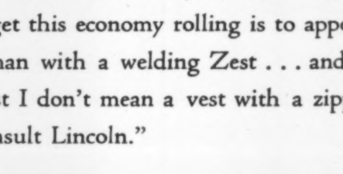

"As I said before, all that's needed to get this economy rolling is to appoint a man with a welding Zest . . . and by Zest I don't mean a vest with a zipper. Consult Lincoln."

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THE LINCOLN ELECTRIC COMPANY

DEPT. C-577 **CLEVELAND, OHIO**

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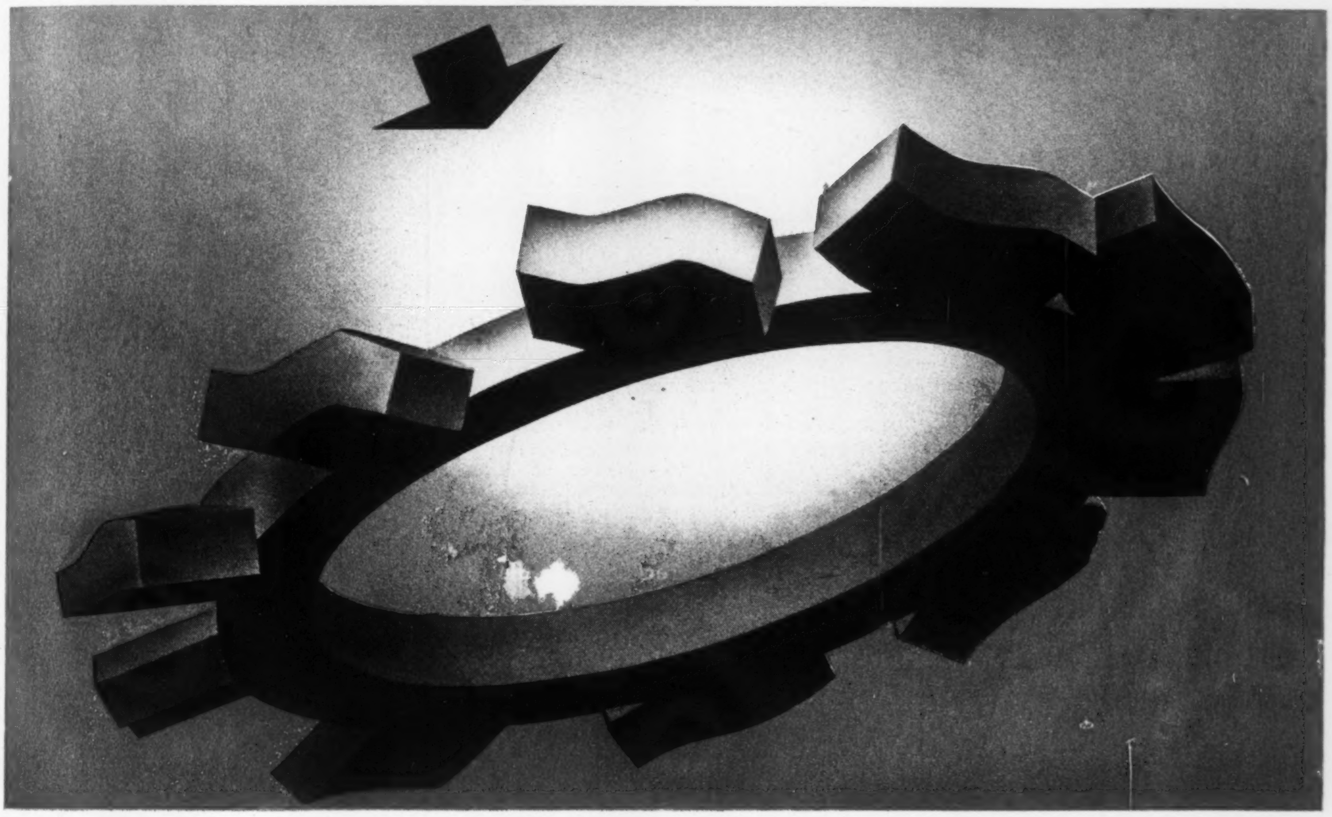

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